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Selected Articles on Gas-Turbine Ro/Ro Ships

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SELECTED ARTICLES ON GAS-TURBINE Ro/Ro SHIPS

Leningrad SUDOSTROYENIYE in Russian No 3, 1980 pp 3-52

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OCEAN AND RIVER

THE LABOR VICTORY OF THE COLLECTIVE

Leningrad SUDOSTROYENIYE in Russian No 3, 1980 pp 3-6

[Article by Yu. I. Makarov, director of the Black Sea Shipyard]

[Text] Fulfilling the tasks posed by the 25th CPSU Congress on supplementing the domestic fleet during the 10th Five-Year Plan with highly productive dry-cargo ships, the collective of the two Orders of Lenin, Order of the October Revolution and Order of the Red Banner of Labor of the Ukrainian SSR Black Sea Shipyard of Communist Labor is building a series of ships with horizontal cargo handling of the "Atlantika" class. The first ship of the series, the "Kapitan Smirnov," became operational in 1978.

Our country's shipwrights developed for the first time a high-speed, horizontal cargo handling vessel with displacement of 36,000 tons, equipped with a gas turbine power plant with rating of 36,780 kW which provides a speed of 25 knots. The loading scheme with two-way movement of truck lifts provided on the ship contributes to significant acceleration of cargo handling. Supplementing the fleet with ships of this class will make it possible to achieve an increase of its productivity due to the high speed and significant reduction of anchor time. According to its technical data, the ship "Kapitan Smirnov" is at the level of the modern achievements of worldwide shipbuilding.

A great deal of attention was devoted during planning to improving the design and selecting the shape of the hull lines and reducing its metal consumption. Measures to improve organization of labor, introduction of leading production processes and to increase the technical level of production were implemented during preparation of production. The analytical method of planning-technological preparation of production using a computer was used in construction of the ship; the hull was formed from flat sections with maximum standardization of assemblies and parts, while the engine room was formed from reinforced zonal blocks and panel installation of the pipes and modular arrangement of the compartments were introduced.

The collectives of scientific research and planning and design organizations, VUZ's and industrial enterprises of the country participated in

working out the design and in building the ship. High labor enthusiasm and the broad scope of the socialist competition contributed to successful completion of the ship's construction, which was designated a Komsomol construction project.

A sampling of articles devoted to the experience of design and construction of the pilot ship of the series "Kapitan Smirnov" is published in this edition of the journal.



Forming the Bow End of the Ship "Kapitan Smirnov"

Implementing the decisions of the historical 25th CPSU Congress and participating actively in the All-Union socialist competition, the collective of the Black Sea Shipyard of Communist Labor, which has won four Orders, is successfully fulfilling increased pledges adopted on construction and turnover of dry-cargo carriers, ships with horizontal cargo-handling method and supertrawlers to the fleet. Implementation of measures to accelerate scientific and technical progress made it possible to raise the level of the main types of production to a new, higher stage and to achieve an increase of product quality.

An important achievement of the shipyard collective was construction of the essentially new ship "Kapitan Smirnov" with horizontal cargo-handling. Development of the series of these specialized vessels designed to transport general cargo in large-cargo packets, wheeled equipment and international

size containers, will contribute to a sharp reduction of transport delays by improving transshipping and warehousing operations, acceleration of cargo delivery and improvement of cargo preservation.

This is not the first time that the shipyard has constructed complex ships. The whaling bases, the "Sovetskaya Rossiya" and the "Sovetskaya Ukraina," the scientific research vessel "Akademik Sergey Korolev" and others were launched from the ways of the shipyard.

Responding specifically to the decisions of the party and government on further development of the socialist competition, all participants in creation of the ship "Kapitan Smirnov"--the designers, the shipyard workers and related workers--concluded an agreement on labor cooperation which provides for working out the technical documentation ahead of schedule, the use of leading production processes and the most efficient forms and methods of labor based on the progressive engineering and technical decisions included in the project. The office of the Nikolayev Municipal Committee of the Ukrainian Communist Party and the Presidium of the Regional Trade-Union Committee approved the initiative of the shipbuilders. An oblast sector staff for the competition was created to coordinate the activities. All this played an important role in increasing production efficiency and improving work quality.

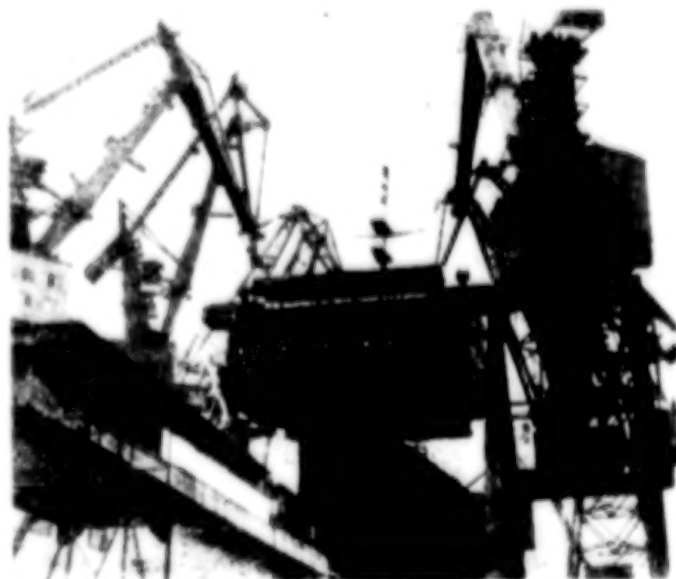
The planning organizations worked out the main propositions on the technology and organization of construction at the stage of coordinating the preliminary and contract designs of the ship and a great deal of attention was devoted to work safety and exclusion of health-hazardous materials. The propositions provided for analytical coordination of the hull lines, treatment of sheet metal on Kristall machines with program control, the use of large sheets, strengthening of the sections on the pre-way assembly sites, combination of copper pipe and machine-installation operations with hull-shaping operations and the maximum possible transfer of installation and prebuilding operations to the shops and to the ways. The designers also provided introduction of the modular method of arranging the cabins in panels from the new construction material "chernomorit," developed by shipyard specialists, and also covering the pipelines of the ship systems with panels. All the design documentation was issued in a form suitable for computer processing.

Agreements on a competition and exchange of leading production experience were concluded between the enterprises and related organizations, shops and brigades linked by a unified production process for modern organization of a wide work front. The complex brigades created from the shipyard workers and designers rendered important assistance in solving operational problems.

The operational results of the competition were summarized monthly by the oblast sector staff jointly with the production committee of the oblast trade-union committee. The decisions on the results of the competition for

the quarter and year were made in the presidium of the oblast trade-union committee with participation of the managers of enterprises and organizations--participants in construction of the pilot ship. The winners were determined by production and planning-design groups. The collectives of the shops, departments, production sections, brigades, offices, individual workers, foremen and engineering and technical personnel, distinguished during different periods of construction, were recommended by a joint decision of the administration and trade-union committees of the enterprises and organizations and the oblast sector staff for entry in the Honor Book.

It is quite natural that construction of the ship "Kapitan Smirnov" was under the unflagging attention of the communist party of the shipyard. The operational party group created by it monitored the course of construction, mobilizing communists for solution of complex and operational problems. The secretary of the party committee Ye. M. Shvets devoted constant attention to fulfillment of the postulated problems.



Installation of Superstructure Block

The shipyard collective undertook construction of the unique gas-turbine ship as a responsible and honored task. More than 20 types of pilot prototypes of new equipment must be introduced to fulfill it, ensuring installation and adjustment of the complex equipment. The lathe operators of the brigade of Hero of Socialist Labor M. A. Malyy, the fitters-installers

A. F. Antonova, I. G. Nekryacha and A. R. Romanova and representatives of many other specialties made an important contribution to solution of complex engineering tasks. The collectives of the finishing, installation-finishing, ship installation, copper pipe and other shops especially distinguished themselves. The collectives of V. I. Pshenichnyy, F. I. Fedortsev and M. T. Ivanenko, who systematically overfulfilled the daily tasks, won the brigade competition. The finishers, working on finishing the holds, tweendecks and installation of the ventilation systems, had to overcome many difficulties and solve complex production and organizational problems and they coped successfully with this. The brigade of winner of the Orders of the October Revolution and the Red Banner of Labor V. I. Yakovenko and also of L. A. Postavnyuk, awarded the Order of the Red Banner of Labor, and of V. D. Kuz'mitskiy, awarded the Order of Labor Glory Third Degree, worked by the shock-labor method. All of them have their personal mark of excellent quality and serve as an example for other workers.

Not only the labor enthusiasm of all the collectives contributed to accelerated construction of the ship "Kapitan Smirnov," but also the circumstance that the forms and methods of organization of labor are being constantly improved at the shipyard, new progressive production processes are being developed and introduced and technical re-equipping is being accomplished. The plan for the 10th Five-Year Plan at the enterprise provides for broad use of the analytical method of determining the forms and dimensions of parts by detail drawings for cutting on machines of "Kristall" type (using a mathematical model and publication of control programs), putting into operation large sheet processing lines and also lines with program control for machining section-rolled steel (which permits non-template layout and machining of the section), the use of high-capacity gantry cranes and construction of pre-way assembly-welding sites (this makes it possible to form ship hulls from blocks of significant mass characteristics shaped into clean dimensions), significant expansion of the section of machine tools with ChPU [Numerical program control] and also extensive introduction of special equipment--machine tools with electrophysical and electrochemical machining, aggregate machine tools and so on. Much of that planned has already been done. A system of zero-defect turnover of a product from the first presentation has been introduced at the shipyard. The number of workers and brigade leaders having the mark of excellent quality who turn over products, clearing the OTK [Department of Technical Control], is increasing constantly. Days of quality analysis have become traditional. All this indicates constant attention to problems of quality and production efficiency on the part of the administration and party, trade-union and Komsomol organizations of the shipyard.

It should be especially emphasized that the communists which comprise the nucleus of the labor collectives coordinate and direct the activity of all mass organizations. The party bureaus in such shops as the assembly-welding, hall-ways, the main machine-assembly, ship-installation and so on work business-like, specifically and in a combat manner. The shipyard party organization now numbers more than 200 party groups created according to

the production structure. It is here, directly at the job sites, that the most important problems of a production and social nature are resolved and the resulting problems of the collective are kept in the field of vision, bringing them to a solution. An important means of education are the party commissions and monitoring of their fulfillment. A check of the multilateral capabilities of communists became their direction toward trade-union and Komsomol work and also for management of other social organizations. The majority of the chairmen of the shop committees and more than half of the trade-union group organizations are now communists at the shipyards.

It was mentioned in the decree of the CPSU Central Committee "On further improvement of ideological and political-educational work" that building a developed socialist society and increasing the material and spiritual potential of the country created great opportunities for implementing the program goals of our party in the field of formation of the communist consciousness of the people. These goals include education of workers in the spirit of high ideological nature and devotion to the socialist motherland and to the matter of a communist attitude to labor and social property. The educational work at the Black Sea Shipyard is one of the main types for communists. The party committee conducts exercises at which the managers study the fundamentals of production pedagogy and psychology and the party organizations of the shops and departments relate with increased attention to education of high spiritual and moral qualities among the collective members.

The ideological and political education of the workers cannot be regarded separately from personnel problems. In directing the activity of the personnel department to appointment, adaptation and training of young workers, the administration and party organization devote a great deal of attention to these problems and primarily to tutorship. The plant is rich in experimental shipwrights who have knowledge of the fundamentals of psychology and pedagogy and know how to relate to people. One of them is lathe operator P. S. Ryabokon', who gave many young machine tool operators a ticket to life. The five Dovgoshey brothers reached occupational maturity under the supervision of this personnel worker. Production foreman A. P. Lomakin, ship pipe layer N. A. Shved, ship assembler V. N. Kisel', brigade leader of assemblers-finishers I. S. Serbin and many others are teaching young people love of labor and skills and are imbuing them with pride for their native enterprise and the ships being launched from its ways. Eight hundred or more tutors (more than 250 of them are communists) are successfully working as chiefs and approximately half of them have been awarded government prizes. Among the tutors are Heroes of Socialist Labor P. N. Borisov, P. N. Shcherbakov, M. A. Malyy and F. V. Khil'ko, production innovators V. A. Opolinskiy, V. M. Yakovenko, M. F. Vetrov and other knowledgeable people and they serve as an example for young people with their attitude toward labor and social work. Yet another real form of supervisory work over young production workers--collective tutorship, which has already proved its advantages--is practiced in some Young Komsomol brigades. Together it is easier to develop a feeling of collectivism and competition

and love of labor and it is easier to carry out political and educational work. V. N. Chernozub skillfully organizes collective supervision for himself in the Young Komsomol Brigade of the hull-building slip shop: both veterans and young people have been entered in the shipyard Book of Honor for success in construction of the ship "Kapitan Smirnov."

The decree of the CPSU Central Committee "On further improvement of organization of the socialist competition" aroused high creative activity of the shipyard workers. There were many calls and beginnings, support and development of which required new methods in organization and improvement of the labor competition. "It is better to work today than yesterday and it is better to work tomorrow than today."--this slogan of the shipyard collective was adopted as a program of action. Fulfillment of high pledges by the workers made it necessary to more completely utilize the production reserves. Many shipwrights validly decided that their main reserve is to consolidate the working day. Thus was born the competition "Full load to working time." Another creative search was also born during the last five-year plan when an important initiative occurred in the brigade of communist labor headed by N. F. Mavrityn: the carpenters-installers proposed that they organize their work on the basis of complex plans directed toward making the labor process more efficient, elimination of unproductive expenditures, improvement of production preparation and in the final analysis an increase of its efficiency. The value of the initiative included the fact that prior to this determination and use of the increase of labor productivity reserves in the brigades and among individual workers were periodic in nature and there was no engineering support and monitoring on the part of the administration over fulfillment of the tasks by each brigade and by each worker. This initiative, universally adopted, has now entered a qualitatively new phase, having determined the further development of the socialist competition.

For example, the work on labor certification of the participant of the competition for fulfilling the tasks of the 10th Five-Year Plan ahead of schedule has now become massive. This document not only brings the volume of the tasks planned by them for the five-year plan to each brigade and worker, it also determines the fraction of their participation in fulfilling the overall government plan assigned to the shipyard collective. The Directorate and shipyard trade-union committee have worked out the conditions for the competition for the rank of "Winner of the Prize of the 10th Five-Year Plan" for purposes of wide dissemination of the initiative of the leading workers on completing the five-year tasks ahead of schedule and also for development of a mass competition to overfulfill the calculated tasks of labor certificates, which was a new stimulating factor in the struggle to increase labor productivity and the quality of the produced product.

Summarizing the results of the work done by the shipyard to develop the pilot gas-turbine ship "Kapitan Smirnov," it should be emphasized that it made it possible to lay the basis for development of a series of ships very

much needed by the national economy. Coping successfully with this difficult order for the Ministry of the Maritime Fleet of the USSR, the Nikolayev shipwrights thus again confirmed that they have a right to bear the high rank of collective of an enterprise of communist labor.
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THE 'KAPITAN SMIRNOV,' THE FIRST DOMESTIC LARGE-CAPACITY, RO/RO SHIP

Leningrad SUDOSTROYENIYE in Russian No 1, 1980 pp 7-9

[Article by S. M. Koslov and D. K. Ivashenko]

[Text] A large number of new classes of specialized ships, including those with ro/ro, the main feature of which is horizontal division of the cargo space with an almost total absence of transverse bulkheads for easier and more convenient movement of cargo along the tweendecks, has appeared in the worldwide commercial fleet during the past 20 years.

The first large domestic ship of this class is the gas-turbine ship "Kapitan Smirnov" (Figures 1 and 2), designed to transport general packaged cargo, wheeled equipment and international-standard containers (including refrigerator containers) in the holds and on the upper deck. The increased speed and lower block coefficient, the high survivability of the ship, the use of gas-turbine power plants with heat-utilization circuit as the main engine, automated compilation of the cargo layout and monitoring of cargo operations and a number of other features considerably distinguish it from similar foreign ships.

Main Elements and Characteristics of Ship:

Length, m	
greatest	227.4
between perpendiculars	204.0
Width, m	30.0
Depth, m	
to upper deck	21.0
to main deck	11.3
Summer draft, m	9.9
Deadweight at draft of 9.9 m, tons	20,075
Cargo capacity, m ³	54,500
Capacity, registered tons	
gross	14,350
net	7,460

Main Elements and Characteristics of Ship (Continued):

Container capacity (6.1 m), units	1,231
Main engine rating, kW	36,780
Loaded speed, knots	25
Sailing range, miles	22,000
Crew, persons	39
Trainees, persons	6
Passengers, persons	6

Cargo handling using small highly maneuverable lift trucks permits cargo to be unloaded in no more than 2-3 days (instead of 8-15 days for universal ships of the same capacity) and approaches in intensity that for container carriers of cellular design. The possibility of loading the upper deck with onshore equipment is also provided.

The ship is designed for class VM * L1 A2 of the USSR Registry and meets the requirements of international conventions for human safety at sea and for prevention of pollution from ships. It is a twin-screw four-deck gas turbine ship with stern location of the engine room and superstructure above it, with a bulbous bow, inclined stern ramp, transom stern, developed bores of the screw shafts and minimum freeboard. Transverse watertight bulkheads with doors are installed to increase survivability on the ship and side fuel tanks are installed along the entire hold. The double bottom space, the fore- and afterpeaks and the side trim tanks hold 3,900 tons of ballast, intake of which provides the ship with the necessary fit and good seagoing qualities in all cases. The inside height of the hold and tween-decks of not less than three meters, the seven-meter passages, the convenient layout and also the adequate strength of the decks and the hold ramp make it possible to transport cargo of wide nomenclature. Lift truck platforms are provided in the middle tween-deck.

The ramp design permits cargo operations to be carried out at distance from the side to the dock of 0.5 to 1.5 meters, difference in the levels of the exit deck and the dock from -2.2 to +5.5 meters, rolling of the ship up to 1° and trim up to 2°. If the ramp is resting freely on the dock, the load does not exceed 29 kN/m² upon contact of them and if the ramp is operating in the automatic mode, the level is maintained at 19 kN/m².

The all-welded hull of the ship is manufactured from steel 09G2 with yield point of 294 MPa; steel VSt.3sp2 and VSt.3sp4 with yield point of 235 MPa is used for the secondary structures. The system of assembly is mixed: the bottom and all the cargo decks in the region of the cargo hold are made according to the longitudinal system and the sides, decks and inner bottom in the ends are made by the transverse system.

The superstructure is installed on two pylons which form a passage along the upper deck in the stern. The crew is housed in single-berth cabins, the senior officers are housed in seven block-cabins and the passengers

and trainees are housed in two-berth cabins. All the living quarters are serviced with a year-round air conditioning system and are equipped with individual lavatories. The engine room shaft is separated from the superstructure to reduce noise in the living quarters. There is a gym and playing area on the open deck, a swimming pool and a room for individual exercises for crew recreation. The arrangement of the rooms is by the modular system with use of panels made from "chernomorit" slabs, the deckhead is finished in fire-resistant plastic or sheets of aluminum-magnesium alloy.

Two main all-condition reversible GATA M25 gas-turbine units with utility circuit having maximum rating of 10,000 kW each at 135 rpm on the output flange of the reducer are installed on the ship as the main engines. The power plant is automated to sign A2, i.e., remote automated control from the chart house and remote control from the TsPU (Central control post) are provided. Power is transmitted to the two four-blade fixed-pitch screws 3.1 meters in diameter, manufactured from high-strength bronze.

The electric power plant consists of three automated diesel generators with rating of 1,000 kW each, two utility turbogenerators used when under way, with rating of 1,000 kW each and an emergency diesel generator with rating of 200 kW. The boiler plant includes two utility steam boilers with productivity of 14 t/hr each, an automated auxiliary boiler with productivity of 6 t/hr at pressure of 490 kPa, which provides steam needs at anchor when the utility boilers are not operating.

The ballast system is made of pipes; ballasting and deballasting are carried out through a double bottom ballast distributing channel. The system is serviced by two pumps with delivery of 250 m³/hr each. There is a special system consisting of two outboard trim tanks and a pump with delivery of 400 m³/hr to equalize roll during cargo operations. Firefighting is accomplished by the following systems: water, liquid, flooding and foam- and carbon dioxide extinguishers. A drainage system serviced by two pumps with delivery of 250 m³/hr each and one with delivery of 25 m³/hr is provided to remove water. Moreover, remotely controlled rotary discharge gates are provided in the upper tweendeck to remove large masses of water overboard.

The life-saving equipment includes two closed boats with capacity of 55 persons each and three inflatable rafts.

Mooring operations are carried out by means of two automatic electric mooring winches with tractive force of 123 kN. The anchor device consists of two electric capstans, two stem anchors and one reserve Hall's anchor with mass of nine tons each; cast chains with gauge of 62 mm are manufactured from high-strength steel. Remote retrieval of the anchors from the wheelhouse is provided. The ship is controlled by a semibalanced rudder, for hoisting of which an electrohydraulic rudder machine with automatic rudder is installed. The torque on the tiller is 2,450 kN·m. A reserve rudder drive is provided. There are bow and stern steering gear with total thrust of 127 kN.

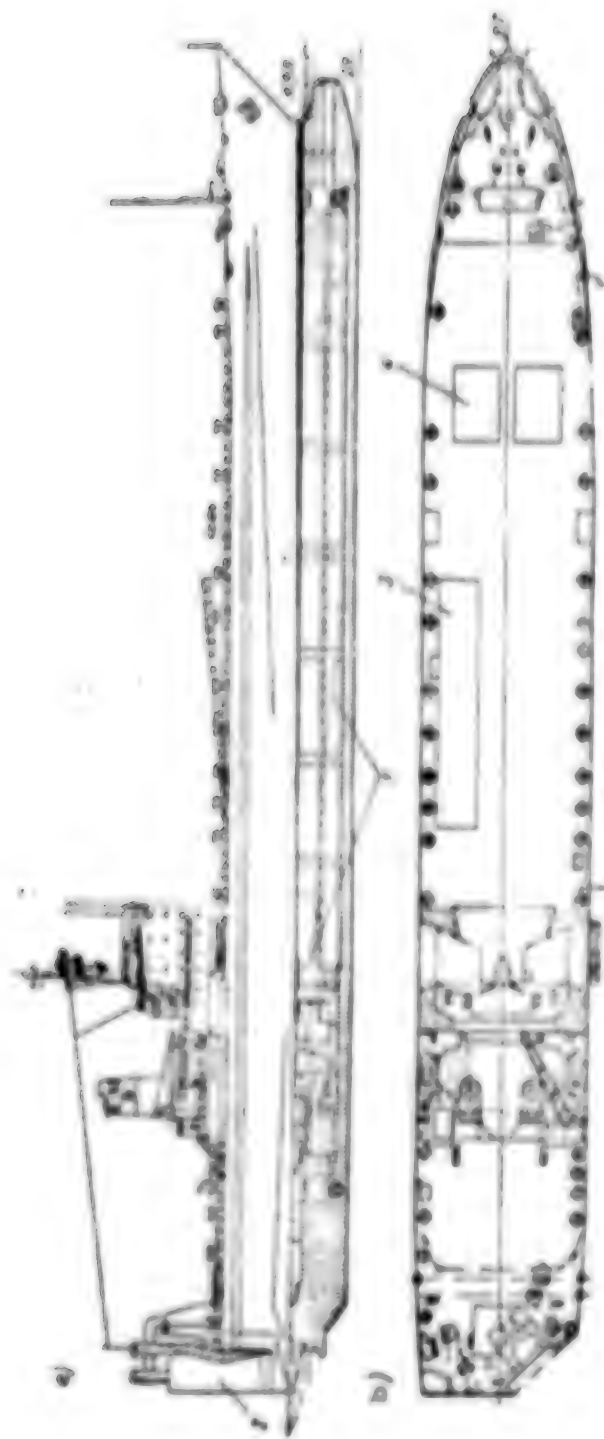


Figure 1. Diagram of Overall Ship Layout: a--side view; b--top view; c--upper deck of super-structure; d--first house deck; e--second house deck; f--third house deck; g--fourth house deck; h--navigating bridge; i--middle deck; j--bulkhead deck; k--lower deck; l--hold; 1--fixed ramp between decks; 2--inclined stern ramp; 3--upper deck exit; 4--hatch cover; 5--chart room; 6--block cabins; 7--single-berth cabins; 8--computer room; 9--two-berth cabins; 10--passenger lounge; 11--pantry; 12--wardroom; 13--officers' lounge; 14--air conditioner room; 15--crew mess; 16--swimming pool; 17--engine room shafts; 18--dispensary; 19--gym; 20--firefighting room; 21--ramp door; 22--engine room; 23--tiller room; 24--steering room

[Figure continued on following page]

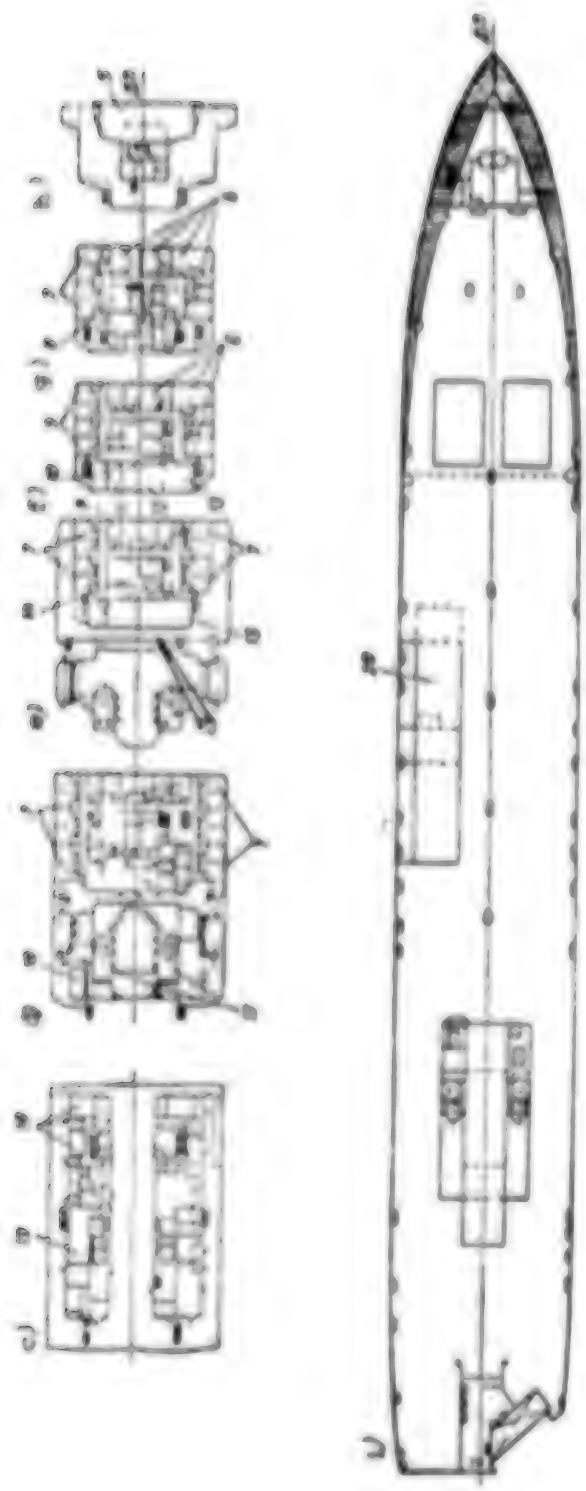


Figure 1 (Continued).

[Figure continued on following page]

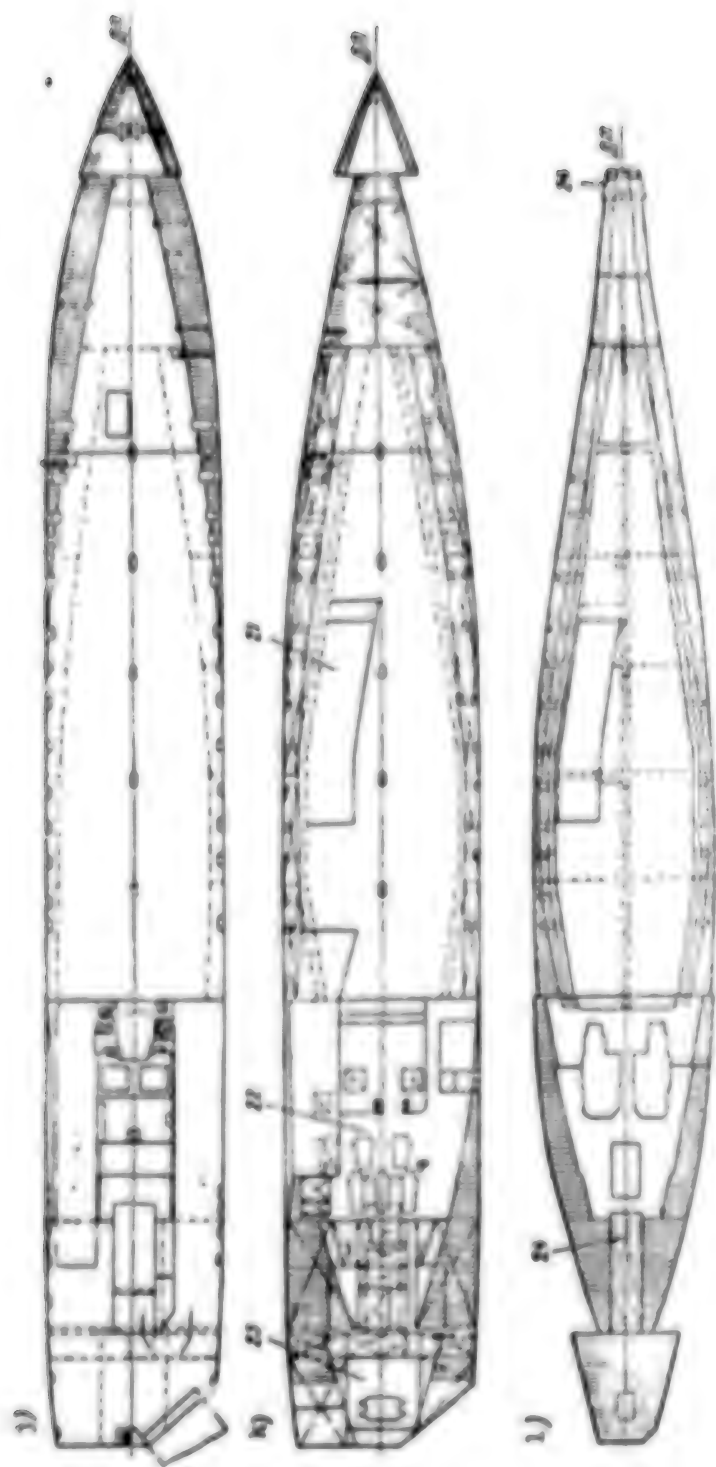


Figure 1 (Concluded).



Figure 2. Gas-Turbine "Kapitan Smirnov"

The ship is equipped with a complex automation system which permits automation of navigation, piloting and problem-solving processes during preparation of cargo operations and control of them. The modern navigation equipment ensures safe sailing for the ship. Cathode protection is provided to prevent corrosion of the underwater part of the hull.

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SELECTING THE SHAPE OF THE SHIP LINES AND THE PROPULSION COMPLEX

Leningrad SUDOSTROYENIYE in Russian No 3, 1980 pp 10-14

[Article by L. A. Sirotnikova, V. K. Turbal and V. N. Shcheredin]

[Text] The high available power of the first domestic large-capacity ro/ro ship and the desire to provide good sailing qualities with high operating reliability of the shafting and the screw-rudder complex considerably complicated the problem of selecting the shape of the hull lines, the geometric characteristics of the screws and arrangement of them. The simplest calculation shows that if the ship's propulsive coefficient is increased by five percent, for example, the consumed power of the main engine to maintain a given speed (25 knots) decreases by approximately 1,840 kW, which corresponds to a fuel saving of approximately 130,000 tons/year. Therefore, special attention was devoted during selection of the shape of the lines and propulsion complex to problems of navigability with regard to the possibility of manufacturing large-diameter screw shafts and to use of proven designs of the shafting and also to maximum use of the space under the decks.

Solution of the postulated problem based on complex model tests in an experimental basin was begun even during selection of the main dimensions of the ship and determination of its architectural-structural type. The following versions of the ship were developed and tested during these investigations (Table 1):

--a single-shaft version with fixed- and adjustable-pitch screws and also with coaxial counterrotating screws;

--a two-screw version with split stern and fixed-pitch screws rotating both inside and outside (Figure 1). This version of the ship was the best in displacement of the main engines, design of the shafting and use of the space below decks;

--a two-screw version with traditional hull lines, struts and developed screw bosses.

Table 1. Comparison of Main Elements and Characteristics of Investigated Versions of the Ship and of the Container Carrier "Euroliner" [1]

(1) Наименование элемента и его характеристика	(2) Основные элементы				(3) Расчетные параметры			(8) Контрактное документация
	(4) с расчетным параметром	(5) с параметром	(6) с параметром	(7) с параметром	(8) с параметром	(9) с параметром	(10) с параметром	
Длина, м (10) по КВЛ (11) Среднее в полном грузу (9)	209,7	207,0	209,7	209,7	209,7	209,7	209,7	200,0
Ширина наибольшая, м (12)	204,0	204,0	204,0	204,0	204,0	204,0	204,0	221,95
Осадка по КВЛ, м (13)	29,8	29,8	29,8	29,8	29,8	29,8	29,8	30,5
Объемное водоизмещение, м³ (14)	9,0	9,0	9,0	9,0	9,0	9,0	9,0	9,965
Мощность энергетической установки, кВт (15)	30 510	30 510	30 510	30 510	30 510	30 510	30 510	36 700
Средняя скорость хода, км/ч (16)	36 780	36 780	36 780	36 780	36 780	36 780	36 780	41 920
Средняя скорость хода, км/ч (17)	7 160	6 650	6 650	6 650	6 650	6 650	6 650	7 740
Коэффициент полезной работы (18)	0,584	0,542	0,542	0,542	0,542	0,542	0,542	0,530
Коэффициент полезной работы, м/с (19)	0,377	0,377	0,377	0,377	0,377	0,377	0,377	0,377
Коэффициент полезной работы, м/с (20)	0,580	0,580	0,580	0,580	0,580	0,580	0,580	0,580
Площадь центра тяжести (21)	1,28	1,28	1,28	1,28	1,28	1,28	1,28	1,28
Отношение длины к ширине (22)	6,85	6,85	6,85	6,85	6,85	6,85	6,85	6,85
Отношение ширины к осадке (23)	3,31	3,31	3,31	3,31	3,31	3,31	3,31	3,31
Среднее в балласте (24)	5,57,0	5,57,0	5,57,0	5,57,0	5,57,0	5,57,0	5,57,0	5,57,0
Осадка в полном грузу, м (25)	—	—	—	—	—	—	—	—
Объемное водоизмещение, м³ (26)	—	—	—	—	—	—	—	—
Средняя скорость хода, км/ч (27)	—	—	—	—	—	—	—	—
Диаметр гребного винта, м (28)	6,5	6,5	6,5	6,5	6,5	6,5	6,5	6,15
Диаметр гребного винта, м (29)	110	110	110	110	110	110	110	115
Частота вращения гребного винта, об/мин (30)	112	112	112	112	112	112	112	115
Частота вращения гребного винта, об/мин (31)	—	—	—	—	—	—	—	—
Отношение центра тяжести к КВЛ, м (32)	—	—	—	—	—	—	—	—
Отношение центра тяжести к КВЛ, м (33)	—	—	—	—	—	—	—	—
Диаметр винта на 1/2 скорости, м (34)	—	—	—	—	—	—	—	—

That of the bow screw is in the numerator and that of the stern screw is in the denominator.

Key (Continued from preceding page):

- | | |
|---|---|
| 1. Name of elements and characteristics | 18. Block coefficient |
| 2. Single-screw version | 19. Midship coefficient |
| 3. Two-screw version | 20. Prismatic coefficient |
| 4. With split stern | 21. Longitudinal position, percent |
| 5. With screw brackets | 22. Length to width ratio |
| 6. With standard developed bosses | 23. Width to draft ratio |
| 7. With developed bosses of finally accepted shape | 24. Ship under ballast |
| 8. Container carrier "Euroliner" | 25. Box/stern draft, m |
| 9. Loaded ship | 26. Displacement, m^3 |
| 10. Length, m | 27. Wetted surface, m^2 |
| 11. Along designer's water line | 28. Screw diameter, m |
| 12. Between perpendiculars | 29. Coaxial screw diameters |
| 13. Greatest length, m | 30. Screw rotational frequency, rpm |
| 14. Draft along designer's water line, m | 31. Coaxial screw rotational frequency, rpm |
| 15. Displacement, m^3 | 32. Distance of center of screw disc from centerline plane, m |
| 16. Power plant rating, kW | 33. Distance of center of screw disc from main plane, m |
| 17. Wetted surface of hull with protruding parts, m^2 | 34. Bosses diameter on 18.5 transverse section, m |

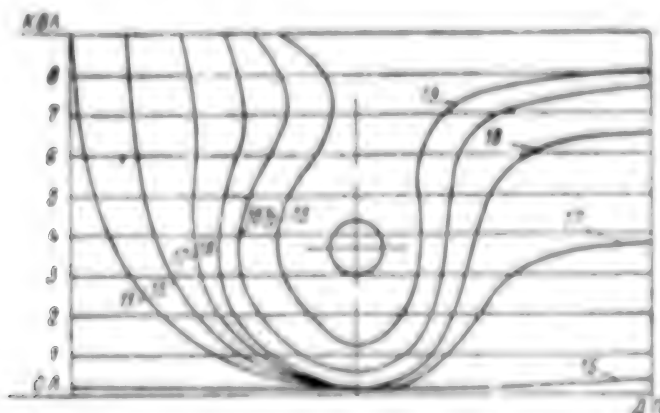


Figure 1. Theoretical Drawing of Stern End of Hull of Two-Screw Version of Ship With Split Stern

All the versions of the ship had a bulb bow whose dimensions and shape were selected on the basis of the experience of designing high-speed ships. Both towing and self-propelled tests were conducted during model investigations. The results of comparative towing tests in the form of curves of the residual drag coefficient of a hull with protruding parts are presented in Figure 2. It is obvious from the figure that a hull with a split stern has the highest towing drag, while a traditional one-screw hull has the least drag and the difference in the values for the worst and best versions comprises 40 percent.

Analysis of the results of comparative calculations of navigability (Figure 3) shows that a single-screw version of a ship with coaxial screws (26.65 knots) has the highest loaded speed, while the version with split stern with inside rotation of the screws has the lowest speed (24.0 knots) with power plant output of 36,780 kW. The speed loss in this version of the ship is even more significant (22.6 knots) with outside rotation of the screws.

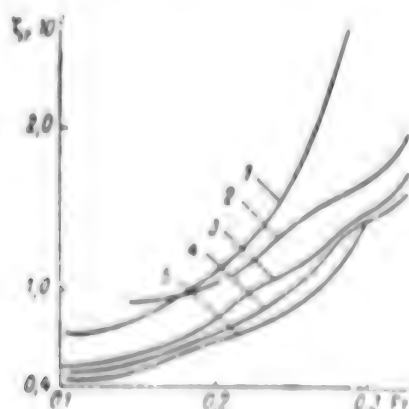


Figure 2. Curves of Variation of Residual Drag Coefficients for Different Versions of a Hull With All Protruding Parts With a Fully Loaded Ship Under Way: 1--two-screw version of ship with split stern; 2--two-screw version of ship with developed bosses of traditional shape; 3--two-screw version of ship with developed bosses of new shape; 4--two-screw version of ship with screw struts; 5--single-screw version of ship.

Significant improvement of the propulsive qualities of a ship with coaxial screws, subsequently confirmed by systematic tests of ship models of other types, is explained by an increase of the screw efficiency by approximately 12 percent and more favorable interaction of the coaxial system with the hull, which leads to an increase of hull efficiency by approximately eight percent.

However, despite the result, this version was not accepted with regard to the absence in shipbuilding practice of proven technical solutions in transmission of high power to coaxial screws. It must be noted that the given developments along with the data of other tests [2, 3] indicate the considerable possibilities of improving the propulsive qualities of ships by using counterrotating coaxial screws.

High navigable qualities were achieved in the single-screw version with ordinary fixed- or adjustable-pitch screw (25.6 knots). Nevertheless, it was subsequently decided not to consider the single-screw version with regard to the absence of reliable design solutions for the screw and shafting with power transfer of 36,780 kW to a single shaft.

The two-screw version of a ship with screw struts is the most widely used in the worldwide practice of building ships of this class and, according to model test data, it has the highest navigable qualities among the considered two-screw versions with screw shaft diameter of 700 mm. However, realization of it encountered a number of technical difficulties related to manufacture of long (23 meters) screw shafts and with provision of a reliable design of the thrust bearings in the struts.

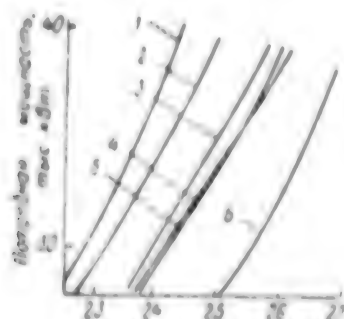


Figure 3. Curves of Required Power as a Function of the Speed of Different Versions of the Ship: 1--two-screw version of ship with split stern; 2--two-screw version of ship with developed bosses of traditional shape; 3--two-screw version of ship with developed bosses of new shape; 4--two-screw version of ship with screw struts; 5--single-screw version of ship with ordinary screw; 6--single-screw version of ship with coaxial screws

Key:

1. Required power, thous. kW

2. Ship speed, knots

It became necessary in this regard to look further for a more rational solution. The version of a ship hull with developed screw bosses, in which the advantages of a split-stern ship were totally retained--the possibility of using short screws and the proven design of a deadwood device--was the version. A shaft corridor with all the required equipment is located in the developed bosses, whose diameter reaches 55 percent of the screw diameter.

As shown by model tests, the required power from the power plant of a ship with traditional developed bosses was reduced by approximately 10 percent compared to the version with split stern, but was approximately 12 percent greater than that of the version with struts. Investigations to improve the shape of the bosses were continued in this regard. Bosses of special shape was developed as a result of taking into account the characteristics of flow formation in the stern end and of the specific operating conditions of the screws beyond the hull of the considered ship.

Calculations from model test data of a ship with developed bosses of new shape showed that its navigable qualities are similar to those of ships with screw struts, having shaft diameter of 700 mm. A decrease of power with given speed for a ship with developed bosses of new shape comprises approximately 10 percent compared to the version having traditional bosses.

Taking into account the results obtained, the version with developed bosses of new shape was adopted as the most efficient to carry out further developments. Equipping the ship with adjustable-pitch screws, manufacture of which in the version with struts and long screws would be very complicated and expensive, and which was suggested during the early stages of design, also contributed to this.

All attention was concentrated during development of the contract design in selecting the shape and arrangement of the developed bosses and also in design of the optimum screws. The main dimensions of the ship were altered somewhat by this time according to general design concepts and the thickness of the bosses was increased in the region of the shaft passages for arrangement of the mechanisms servicing the shafting.

The whole prismatic coefficient was reduced by increasing the midship coefficient to further reduce towing drag. All the model tests and calculations carried out during preliminary design indicated the possibility of reducing the screw diameter to 5.7 meters without a loss for ship navigability and with provision of an adequate reserve against impermissible blade cavitation occurring. This measure permitted not only a reduction in the cost of the screws and load transmitted to the shaft but also a reduction of the boss dimensions while providing appropriate clearance according to vibration concepts between the screw blades and the hull planking.

Based on analysis of the data from investigating fluctuating pressures in the ship hull, which occur during operation of the screws, the boss dimensions and arrangement of them beyond the hull were selected so that the clearance between the blades and planking comprised not less than 28 percent of the screw diameter. The discs were brought closer to each other for more complete use of the viscous weight energy of the hull and to improve the interaction of the screws with the hull, so that the distance between the screw axes comprised 1.8 of their diameter. As indicated by observations during model tests, the indicated displacement of the screws toward the center-line plane led to the fact that the rudder is in the water flows separating from the screw even at small angles of placement. This undoubtedly contributes to improvement of controllability, especially at low speeds and at the beginning of ship motion.

After the main dimensions and the optimum coefficients of theoretical drawing and also the dimensions and arrangement of the screws were selected, all further investigations were directed toward working out the shape of the bosses, arrangement of the bilge keels and toward obtaining the materials for calculation of ship navigability and toward design of the screws

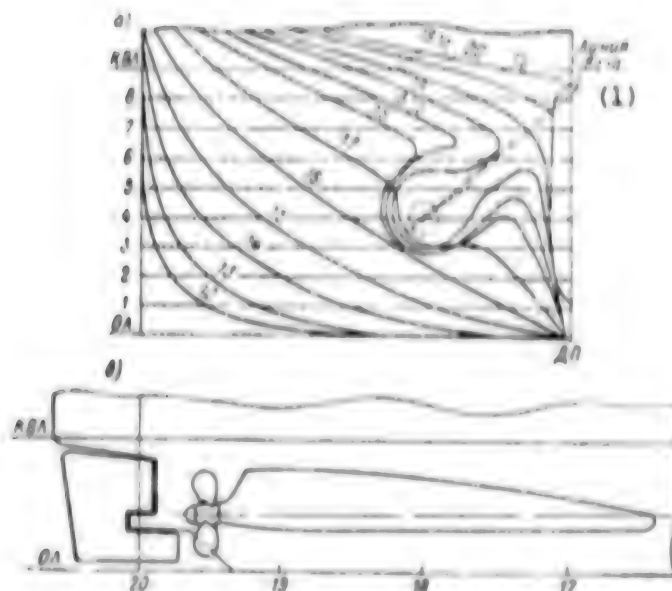


Figure 4. Theoretical Drawing (a) and External View (b) of Finally Adopted Developed Bosses

Key:

1. Shaft line

and determination of the loads transmitted to the shaft. The following were carried out to solve the postulated problems:

--towing tests of a model with different versions of developed bosses and bilge keels (solid, sectional and truncated) with closed and open steering gear channels;

--self-propelled tests of the model with different versions of the developed bosses with the ship under way while fully loaded and in ballast;

--measurement of the velocity field in the screw disc for the finally adopted version of the hull with protruding parts.

When conducting model tests of a two-screw ship with developed bosses, unfavorable streamlining of the traditional bosses having cylindrical shape with arrangement of the strut normal to the hull surface was noted. Their drag coefficient comprised $0.69 \cdot 10^{-3}$, i.e., approximately 25 percent of the total drag. Hull efficiency was also reduced appreciably compared to the "strut" version (0.85 instead of 0.95). Moreover, the absence of rudders behind the screws did not permit a return of at least part of the losses to twisting of the flow by the screws by using them. A reduction of the losses could be achieved in this case only by preliminary twisting of the flow in the direction opposite screw rotation due to the corresponding



Figure 5. Stern End of Ship

shape of the stern end lines and mainly of the shaft bosses. Therefore, the angle of inclination of the struts of the new shaped bosses to the main plane was reduced to 11° for preliminary twisting of the flow impinging on the screws.

Comparative model tests showed that the additional drag of the bosses at $Fr = 0.24-0.30$ can be appreciably reduced due to favorable wave interference with displacement of the greater part of the volume of the boss toward the water line and toward the stern. The noted circumstances were taken as a basis when developing the bosses of new shape (Figures 4 and 5).

The values of the residual drag coefficients were determined after final selection of the shape of the hull with all protruding parts (developed bosses, truncated bilge keels and arrays of the steering gear channels) (Figure 6). It is obvious that the residual drag coefficient of the hull with finally designed lines is close to that obtained during testing of a series of models of high-speed shifts and is also close to the coefficient for the container ship "Eurpliner" (FRC), having two struts each on each screw: a main and auxiliary in the mid-part of the shaft. Thus, the developed shapes of the lines and the thickened developed bosses made it possible to achieve good characteristics of navigability and to use short screws on the designed ship (10.5 m) with design of the dead-end device proven in practice.

Key (Continued from preceding page):

- | | |
|---|--|
| 1. Name of characteristic | 8. Maximum thickness of blade cross-section, mm |
| 2. Four-blade screw | 9. Relative thickness of cross-sectional profile |
| 3. Seven-blade screw | 10. Deflection point of mid-line of profile, mm |
| 4. Relative blade radius | 11. Relative curvature of mid-line of profile |
| 5. Spacing ratio | |
| 6. Blade width, m | |
| 7. Distance of entering edge from generatrix, m | |

Measurements of the velocity field in the screw disc indicated significant equalization of it when using developed bosses of the new shape. At the same time the circumferential nonuniformity of flow in the screw disc is still sufficiently high. Thus, for example, a maximum decrease of the axial velocity compared to the mean velocity during rotation on relative screw radii of $r = 0.7-0.9$ comprises 12 percent, while an increase of it comprises approximately 10 percent of the ship speed.

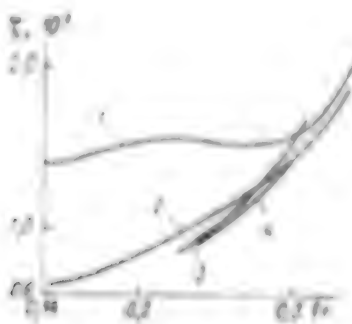


Figure 9. Curves of Variation of Residual Drag Coefficients of Hull With All Protruding Parts: 1--adopted version of hull with developed bosses in ballast from model test data ($T_H = 5.5$ m and $T_K = 7.0$ m); 2--adopted version of hull under full load according to model test data ($T_H = T_K = 9.0$ m); 3--calculation of series of domestic container carriers from test materials; 4--container carrier "Euroliner"

A considerable volume of developments and model tests was carried out during selection of the screw configuration which provides the maximum achievable efficiency, the absence of dangerous blade cavitation from the viewpoint of erosion breakdown and minimum values of periodic loads on the hull and shafting.

It was initially proposed that variable-pitch screws be installed on the ship to improve its maneuvering characteristics and that nonreversible main engines be used. The developments carried out during design showed that a ship with variable pitch screw has no appreciable advantages in reversible

Table 2. Main Characteristics of Investigated Propellers

Наименование параметра (1)	Исследуемый винт (2)									
Относительный радиус лопасти (4)	0,3	0,4	0,5	0,6	0,7	0,8	0,9	0,95	0,975	
Площадь сечения (5)	1,171	1,201	1,221	1,229	1,215	1,190	1,160	1,122	1,111	
Средняя толщина, м (6)	2,003	2,197	2,344	2,477	2,580	2,569	2,325	1,961	1,758	
Относительная величина отклонения от образующей, м (7)	0,090	1,078	1,124	1,182	1,141	1,084	1,800	0,659	0,481	
Максимальная толщина сечения лопасти, мм (8)	200,7	172,1	143,5	114,9	86,3	58,0	27,5	31,0	29,7	
Относительная величина отклонения профиля лопасти (9)	0,100	0,0785	0,0712	0,0613	0,0330	0,0222	0,0164	0,0103	0,0079	
Площадь поверхности сечения лопасти, мм ² (10)	53,5	53,8	55,1	53,2	52,4	51,8	45,1	39,2	34,4	
Относительная величина отклонения профиля лопасти (11)	0,0337	0,0245	0,0277	0,0215	0,0205	0,0192	0,0197	0,0134	0,0097	

Сравнительный винт (3)

0,3	0,4	0,5	0,6	0,7	0,8	0,9	0,95	0,975	
1,311	1,290	1,284	1,295	1,240	1,224	1,190	1,180	1,179	
1,422	1,863	1,665	1,775	1,813	1,740	1,605	1,442	1,248	
0,701	0,759	0,780	0,790	0,774	0,680	0,580	0,408	0,283	
176,5	153,2	126,2	101,9	76,0	53,2	32,9	28,7	25,5	
0,171	0,0980	0,0798	0,0574	0,0419	0,0358	0,0305	0,0198	0,0201	
31,8	31,4	29,1	26,9	25,9	25,9	23,6	20,1	23,1	
0,029	0,0114	0,017	0,0153	0,0143	0,0145	0,0142	0,0181	0,0199	

¹ Screw diameter of 9.7 m, disc ratio of 0.79 and ratio of hub and screw diameters of 0.23.

² Screw diameter of 3.6 m, disc ratio of 0.9 and ratio of hub and screw diameters of 0.23.

[Pay on following page]

characteristic for the adopted power plant. The main engine designer investigated the possibility of manufacturing a reversible gas-turbine engine with insignificant losses of economy during forward motion. Since a variable-pitch screw did not provide the ship with advantages in navigability, it was decided to install fixed-pitch screws on it. This decision created the prerequisites for using screws with increased number of blades on the ship, distinguished by a significant reduction of the periodic load amplitudes transmitted from the screws to the ship hull.

Strength specialists carried out calculated analysis of the frequency characteristics of the hull for the main types of vibrations to select the rational number of screw blades which eliminates the appearance of overall resonance vibration of the ship. This analysis showed that the number of screw blades can be assumed equal to four or seven to eliminate resonance vibrations of the hull under full power on the considered ship. The design of both screws adopted to operate in the accompanying flow behind the ship hull was accomplished on the basis of the vortex theory of the supporting surface on a computer (Table 2).

It must be emphasized that the total blade area of a seven-blade screw with equal cavitation reserve is significantly higher than that of a four-blade screw. This leads to an increase of its mass and cost and also to a reduction of efficiency. The noted circumstances were the main reason to reject the use of seven-blade screws on the ship and all further efforts were directed toward working out the configuration of four-blade screws and determination of their hydrodynamic and cavitation characteristics. A model of a right screw 200 mm in diameter, which was tested in an experimental basin and cavitation tube, was manufactured for this purpose.

The results of the tests confirmed the correctness of selecting the geometric elements of the screws and were used to calculate the ship's navigability and cavitation intensity of the blades. It is obvious from Figure 7 that the results of the calculations and full-scale tests essentially coincide.

The pressure fluctuations on the hull planking above the screws were measured during expanded sea trials and observations of the screw operation were made through special ports with stroboscopic lighting. Preliminary analysis of the data confirmed that the value of the pressure fluctuations on the hull planking were insignificant. The pressure fluctuation amplitude of blade frequency comprises approximately 4.9-7.8 kPa, which is somewhat below the mean statistical data for ships of this class [4, 5]. According to this, the total hull vibration was also insignificant.

It should be noted in conclusion that the shape of the ship lines, configuration and arrangement of the developed booms behind the hull, developed on the basis of comparative model tests, and also the screw configuration provided the ship with high navigable qualities.

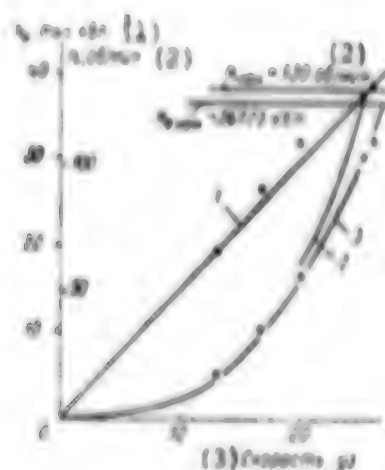


Figure 7. Variation of Consumed Power (N_e) and Rotational Frequency of Screws (n) of Ship "Kapitan Smirnov": 1--variation of n while under way under ballast ($T_N = 5.5$ m and $T_K = 7.0$ m), calculated from model test data; 2--consumed power under full load ($T_N = T_K = 9.0$ m), calculated from model test data; 3--consumed power under ballast ($T_N = 5.5$ m and $T_K = 7.0$ m); $\cdot$ and $\times$ --results of measurements made during sea trials of ship "Kapitan Smirnov" while travelling under ballast

Key:

- | | |
|----------------|-----------------|
| 1. Thousand kW | 3. Speed, knots |
| 2. Rpm | |

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MODEL AND FULL-SCALE TESTS OF SHIP STEERABILITY

Leningrad SUDOSTROYENIYE in Russian No 3, 1980 pp 14-16

[Article by A. I. Nemzer and V. N. Shcheredin]

[Text] Investigations to ensure ship steerability, carried out at all design stages, had the goal of finding high indices of turnability and stability of the ship on course and also in the turning circle.

According to established practice, the characteristics of steerability were determined experimentally on self-propelled models. The capability of the ship to develop a speed up to 25 knots determined the need to consider a number of versions of the project, the steerability of which was investigated in several steps (Table 1). All the versions were tested on models under loaded draft and at a speed corresponding to 25 knots. Moreover, the final version of the ship was tested under ballast.* The initial transverse metacentric height, which comprised approximately 0.5 m with draft of a real loaded ship, was also modelled during the tests.

Two-screw with split stern and single-screw versions of the ship were used as the initial versions at the beginning of the investigations. Tests of a model of a two-screw version with split stern showed that it has unsatisfactory maneuverability--the minimum value of the relative turning circle diameter D/L comprised 5.8 (when designing seagoing transport ships at $Fr \leq 0.3$, one usually strives for $D/L \leq 4$). Moreover, the value of the angle of heel in turn exceeded the specification value of 10° (see Table 1).

It should be noted that it is known from investigations of the controllability of transport ships with U- and V-shaped frames in the stern end that poor maneuverability characterized by a value of $D/L = 5.8$ is accompanied by less heel in a steady turn than that of a ship with a split stern. The reason for this is that the presence of spaces extended in length and located along the side in the stern end imparts resistance to motion and thus

*The main experimental investigations with models were carried out by L. V. Rusetskaya.

Table 1. Characteristic of Steerability of Different Versions of Ship Design

(1) Наименование характеристики	(2) Ориентировочный градусный радиус поворота	Двухвинтовые варианты (3)				
		Двухрулевые		Однорулевые (5)		
		(6) с разделенным рулем	(7) с стандартными разработками руля	со стандартными разработками оборудования		(11) с развитыми базисными разработками оборудования руля
				(9) Нормальный руль	(10) Адаптированный руль	
Площадь руля (рулей), м ² (12)	29,4	2 × 18,6	2 × 19,7	29,9	43	43,3
Минимальный относительный диаметр установившейся циркуляции (13)	4,2*	5,8	3,8	3,8	3,4	3,1
Критический угол перекладки руля, град (14)	0	0	0	5	1-1,5	1
Максимальный угол крена на установившейся циркуляции, град (15)	5	11	10,2	11	9,3	10

* For right-turning circle in the numerator and for left-turning circle in the denominator.

Key:

- | | |
|--|--|
| 1. Name of characteristic | 9. Initial rudder |
| 2. Single-screw, single-rudder version | 10. Adapted rudder |
| 3. Two-screw versions | 11. With developed bosses of finally adopted shape |
| 4. Two-rudder | 12. Rudder area, m ² |
| 5. Single-rudder | 13. Minimum relative diameter of steady turning circle |
| 6. With split stern | 14. Critical angle of helm, deg |
| 7. With standard developed bosses | 15. Maximum roll angle during steady turning circle, deg |
| 8. With standard developed bosses | |

deteriorates the ship's maneuverability. At the same time vertical spaces obviously reduce the Z-axis of the point of application of the hydrodynamic force in the hull, which leads to an increase of the angle of heel in turn.*

* Ya. I. Voytkunskiy, R. Ya. Pershite and I. A. Titov, "Spravochnik po teorii korabliya" (Handbook on the Theory of Combat Vessels), Leningrad, Sudostroyeniye, 1973.

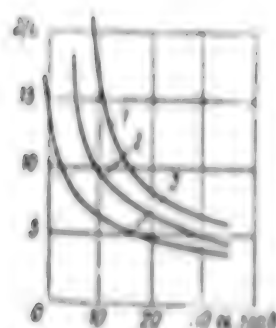


Figure 1. Dependence of Relative Diameter of Steady Turn on Angle of Helm (α): 1--two-screw version with split stern; 2--single-screw version (right turn); 3--single-screw version (left turn)

The controllability of a single-screw ship compared to the version with a split stern is better (Figure 1), which is explained by the high efficiency of the rudder located in the weight and also by the well-developed shape of the stern end. However, neither the single-screw version nor that with split stern were accepted for further development due to unsatisfactory cruising characteristics. The two-screw version with developed bosses and two types of steering gear--one rudder in the center line plane and two rudders located behind the screws--was adopted as the basis during subsequent stages of design.

The results of an experimental investigation carried out on a model with two rudders were on the whole satisfactory. However, it was determined that a model with this version of steering gear pitches severely on a straight course during periodic turns of the rudder. This phenomenon is explained by the combination of the adequately effective rudder and the low stability of the ship. Design measures which reduce pitching, for example, reduction of the area and changing the configuration of the rudders with simultaneous decrease of the deadwood area, were not worked out since the adopted architectural type of the stern did not permit the use of two rudders. Therefore, all subsequent investigations were carried out only with a single-rudder version of a two-screw ship, adopted as the final version from data of investigating maneuverability.

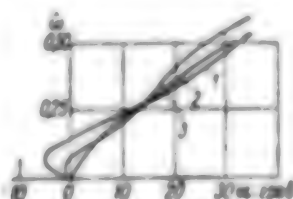


Figure 2. Diagram of Controllability for Two-Screw Versions of Ship With Developed Bosses: 1--with two rudders; 2--with single rudder approximately 30 m^2 in area; 3--with single rudder 43 m^2 in area; $\omega = L/R$ (R is the turning radius)

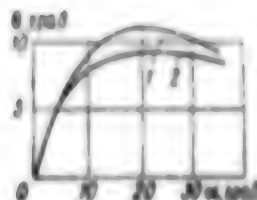


Figure 3. Dependence of Angle of Heel in Steady Turn on Angle of Helm for Two-Screw Version of Ship With Single Rudder: 1--for rudder approximately 30 m² in area; 2--for rudder 43 m² in area

Tests with a rudder approximately 30 m² in area showed that the controllability of the ship was extremely unsatisfactory in this case--it is unstable on course and the critical angle of helm exceeds 5°, i.e., when the rudder is turned 5° in the direction opposite to the direction of rotation, the ship continues to turn (Figure 2). This is explained by the fact that installation of the rudder outside the weight reduced its efficiency. Moreover, arranging the bosses with large inclination to the center line plane reduced the stabilizing effect which they usually have.

Moreover, a ship with two screws is generally less stable on course than a single-screw ship since one of the factors affecting the stability of motion is the arrangement of the frame intermediate between those of U- and V-shape. It is known that shifting the boundary frame to the stern of the ship reduces its stability; comparison of two- and single-screw versions confirmed this. Thus, the indicated frame is located closer to the 17th theoretical frame on a ship with two screws whereas it is located between the 15th and 16th theoretical frames on a single-screw ship. The simplest method in the given case which permits improvement of ship stability on course and at the same time reduces the angle of heel in turn was an increase of the rudder area (see Table 1 and Figures 2 and 3).

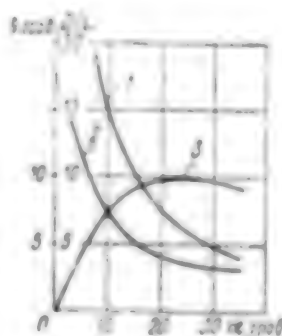


Figure 4. Results of Model Tests of Final Version of Ship: 1--D/L for ship under ballast ($T_n = 5.5$ m and $T_x = 7.0$ m); 2--D/L for loaded ship ($T = 9.0$ m); 3-- θ for loaded ship

Final investigations to determine the characteristics of ship controllability were carried out on a model made with respect to the final lines drawing plan, according to which the shape and arrangement of the boxes were changed on the new model; the tests were conducted with a rudder of increased area (Figure 4). It is obvious from the figure that satisfactory characteristics of controllability were achieved for the final version of the ship on the basis of model experiments.

Table 2. Turning Time of Ship B: 360°, Minutes

Sea experience (1)	Ship pattern (2)		
	maneuver 1.5° (3)	maneuver 15° (4)	maneuver 45° (5)
11 passes (6)	39	36	20.2
10 runs (7)	27	43	18.

Key:

- | | |
|---------------------------|--------------------------|
| 1. Type of turn | 5. Of both steering gear |
| 2. During operation | 6. Right |
| 3. Of bow steering gear | 7. Left |
| 4. Of stern steering gear | |

Full-scale investigations were carried out during turnover trials of the ship "Kapitan Smirnov" when cruising under ballast ($T_n = 5.6$ tons and $T_k = 7.5$ meters). The diameter of steady turn is determined by means of the log and compass whose readings are fixed in time. The value of the diameter of steady turn based on the obtained data was found by the formula

$$D = 30.1 \frac{t}{\Delta\varphi} v$$

where t is the turning time of the ship in the steady turn mode by angle $\Delta\varphi$ and v is the speed in a steady turn.

Moreover, the trajectory was recorded by means of an automatic position plotter. The results of determining the turn diameters by both methods were almost identical. Based on the measurements and calculations, the dependence of the relative diameter of steady turn on the angle of helm (Figure 5), which essentially coincided with the corresponding curve of model tests, was constructed. Some disagreement can be explained by the difference in the fit of the model and of a real ship and namely by the effect of the greater trim to the stern during full-scale tests, improved stability and deteriorated steerability and by an increase of the average draft which usually leads to improvement of steerability.

Tests were also carried out to determine the turning time of the ship without speed during operation of the steering gear (PI)--bow and stern with

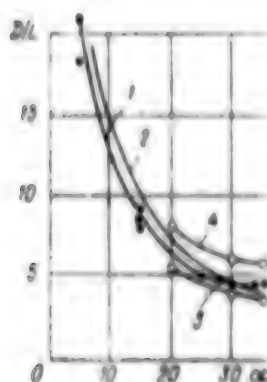


Figure 5. Main Results of Full-Scale Tests of Ship in Turn: 1--full-scale tests; 2--model tests; 3--full-scale tests when cruising with a single operating screw (turn in a direction opposite to the side); 4--full-scale tests when cruising with a single operating screw (turn in the direction of the side with the operating screw)

thrust of 69 kN each, located 174 meters from the midship frame, respectively (Table 2).

A number of maneuvers such as "zigzag," "human rescue," "on-off" operation of the screws and so on was also carried out during full scale tests, which permit qualitative evaluation of ship controllability. The results confirmed the conclusion of the satisfactory controllability of a ship made on the basis of model tests.

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IMPROVING THE DESIGN OF THE SHIP HULL AND REDUCING THE HULL STEEL WEIGHT

Leningrad SUDOSTROYENIYE in Russian No 3, 1980 pp 16-19

[Article by G. O. Taubin, G. V. Boytsov, I. K. Ivanitskiy and Ye. G. Yassiyevich]

(Text) It became necessary during development of the first domestic large-capacity ro/ro ship to review the traditional approaches to hull design and at the same time deal with planning a complex of theoretical and experimental investigations to provide strength and reliability of the hull structures with minimum mass of them. The method of cargo loading and transportation on the decks, the high inertial forces arising during motion of the ship in swells required implementation of a number of design measures which would affect improvement of the operational characteristics and would reduce the metal consumption of the ship.

With regard to the absence of requirements on ships of this type in the Rules of the USSR Registry, the rules of foreign classification societies were analyzed, which showed that there is no regulation of the dimensions of most hull couplings specific to ships with ro/ro. Problems of designating the thickness of the planking and the dimensions of the supporting stiffness ribs are eliminated with different completeness, but the values of these parameters also have a significant spread.

The TsNII [Central Scientific Research Institute] imeni Academician A. N. Krylov and branch laboratories of the Leningrad Shipbuilding Institute and the Kaliningrad Technical Institute of the Fishing Industry and Economy participated in solution of the postulated problems; the TsNII imeni Academician A. N. Krylov coordinated the work of the branch laboratories. A. G. Arkhangorodskiy, L. I. Belen'kiy, V. S. Garbuz, V. A. Dmitriyev, E. I. Ivanyuta, V. N. Kustov, O. Ye. Litonov, V. I. Polyakov, B. Ya. Rozendent, V. Ye. Segal' and S. S. Khalyuk made an important contribution in carrying out the total complex of investigations.

Problems which had to be resolved in fulfilling the scientific research work proceeded from the design features of the ship (Figure 1):

- the absence of transverse bulkheads in the cargo space;
- the presence of fixed sloping ramps connected to the main longitudinal members of the hull and which connect the decks;
- the presence of notches of great length in the decks near the sides to provide travel of loading equipment from level to level;
- the need to provide minimum and identical height of the deck framing;
- the essentially kneeless connection of the deep beams to the frames;
- the presence of large concentrated forces acting on the plates and frame of the deck planking and of the double bottom when loading wheeled equipment.

The absence of transverse bulkheads in the greater part of the ship's length led to the fact that the spatial stiffness of the hull was somewhat lower than that of ordinary dry-cargo ships of the same displacement, i.e., the stress state under the action of operating loads should be analyzed with regard to the spatial deformation of the hull. The problem was to determine the extent to which the distortions in the shape of the transverse sections of the hull were significant due to the absence of bulkheads and to what degree these distortions were reflected in its stress state and also the extent to which the existing traditional schemes of estimating strength can be used in design.

The absence of an adequately reliable theoretical solution of the problem on the stress-strain state of a hull of a ship with ro/ro as a thin-walled three-dimensional elastic system at the moment of design determine the need to carry out experimental investigations. The operating conditions of inclined ramps in the hull (including them in the general bend and loading the connection assemblies with the decks) were also of specific interest.

These investigations were conducted at the LKI [Leningrad Shipbuilding Institute] under the supervision of V. s. Garbuz and at KTIRPKh [Kalinin-grad Technical Institute of the Fishing Industry and Economy] under the supervision of A. G. Arkhangorodskiy and B. Ya. Rozdent, where a model of a plexiglass hull in a scale of 1:30, which repeated the main design features of the full-scale model (Figure 2), and a design-similar model of tin in a scale of 1:80, respectively, were manufactured. Both models were tested for bending, deflection and torsion and also for bending in the horizontal plane. Besides problems of using traditional methods of calculating the strength of ships with ro/ro, specific problems were resolved on each model: the participation of sloping ramps in the total bending of the hull and stress concentration in the angular joints of the ramps and decks in the plexiglass model and the effect of possible depressions in the planking of the upper deck to the stress state of the hull in the tin model.

Key (Continued from preceding page):

1. Design features of ship
2. Problems caused by design features
3. By vibration
4. By overall longitudinal strength
5. By local strength
6. Total vibration of ship
7. Local vibration of ship
8. Absence of longitudinal and transverse bulkheads in region of cargo holds
9. Stability of deck planking
10. Check of possible stress deviations in total bend from plane sections regulated by hypothesis
11. Strength of transverse bulkheads assuming reactive forces of decks during horizontal bending
12. Presence of ramps for cargo transport
13. Inclusion of longitudinal frame beams in general bending
14. Strength of side frame receiving force during horizontal bending of decks
15. Large concentrated loads on plates and ribs of frame
16. Horizontal bending of decks
17. Strength of cargo deck planking
18. Inclusion in total bend of ramps
19. Equal height of deck frame
20. Participation of deck planking with initial deflection in total bend
21. Strength of longitudinal ribs of cargo decks
22. Operation of deck and bottom planking interconnected by pillars during loading of all or some decks
23. Notches of large dimensions in decks
24. Reinforcement of notches at stress concentration points

The experimental investigations made it possible to avoid making the hull excessively heavy even during the first stages of design and to reach the following main conclusions:

--the deck planking is essentially completely included in the work of the hull during general bending of the ship;

--the longitudinal enclosures are completely included in the work of the sloping ramp between the upper and middle decks;

--the presence of depressions in the planking of the upper deck with a deflection pointer equal to the thickness of the planking increases the stresses in the stiff connections by approximately 10 percent;

--the maximum normal stresses were insignificant with total twisting of the hull.

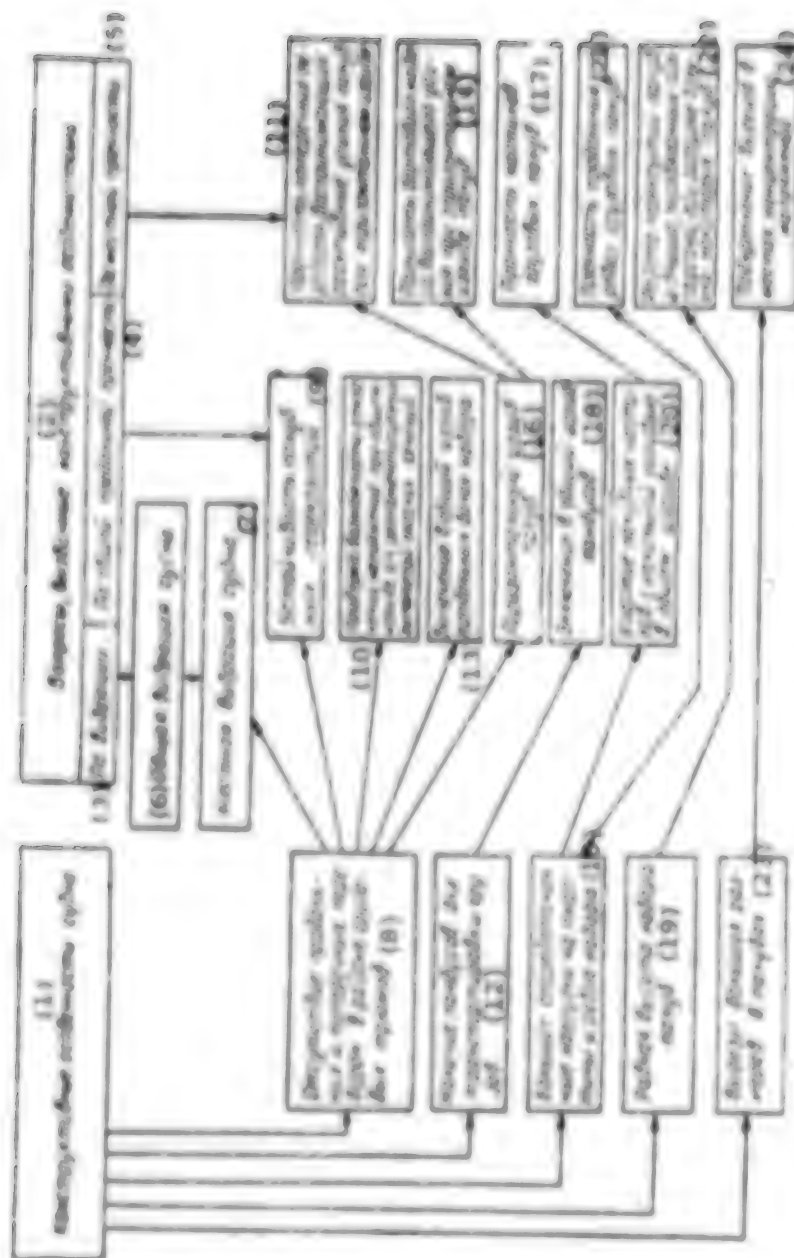


Figure 1. Relationship of Main Design Characteristics of Ship and the Strength Problems Caused by Them

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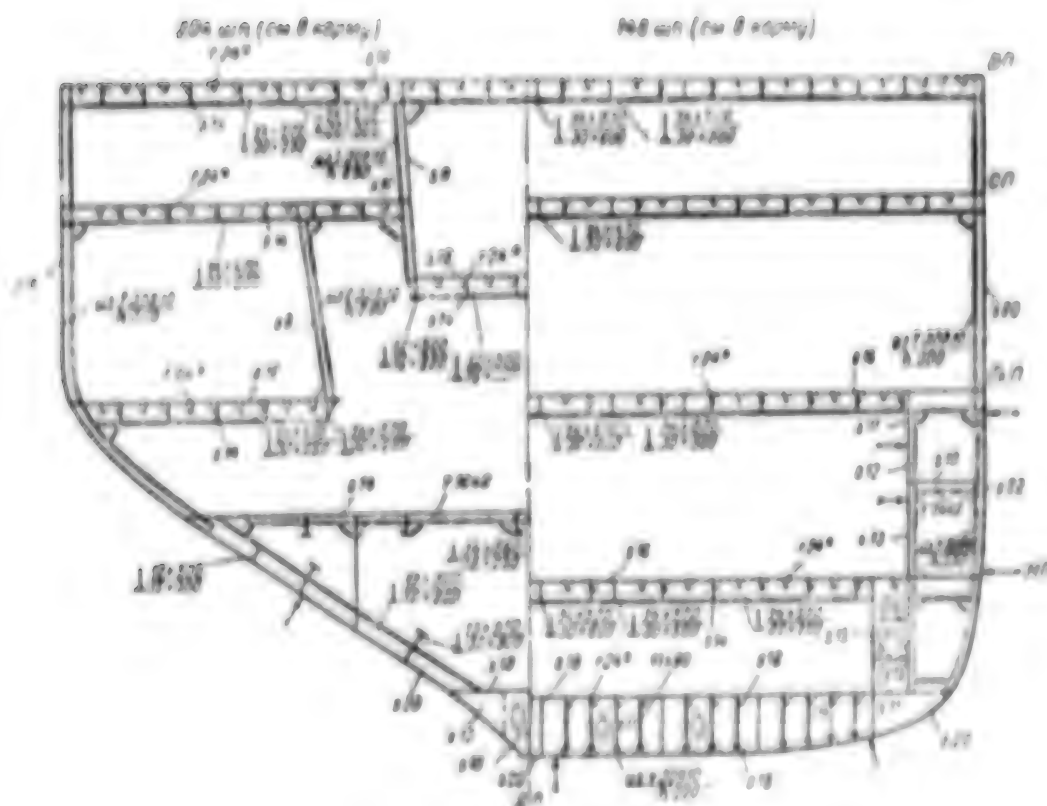


Figure 2. Structural Midship Frame of Ship

The large spans of the deck planking, the various types of irregular structures (reinforced beams, pillars and notches) and the significant variability of the axial forces along the length of the longitudinal beams were the reason that the classical methods of solving the problem of stability of the deck planking was unacceptable. V. Ye. Segal' developed a numerical method for calculating the stability of planking using a digital computer. Calculation of the stability of the upper deck planking showed that the critical stresses for the carlings is equal to the yield point of steel with stiff uncut pillars. Moreover, since one of the features of ships of this class is the low level of compressive stresses in the upper deck when the ship is located in a wave trough, the stability of the planking is also provided when the pillars are cut and crimped.

The high output of the main machinery and the absence of experimental data in domestic shipbuilding in vibration of large-capacity vessels with ro/ro served as the basis to conduct extensive numerical investigations of the dependence of the parameters of the total hull vibration on a number of factors. Along with numerical investigations, the results of which were used in design, it is planned to conduct extensive experimental investigations to study the vibration of the ship during operation. These investigations will help to refine the existing calculating methods and to work out the corresponding recommendations.

The cargo decks of ships with ro/ro are the most crucial hull members whose operation largely determines the possibility of using the ship according to designation. One of the main criteria for normal operation of cargo decks is the values of their vibrational parameters, which in turn depend on the presence or absence of resonances of the main oscillation frequencies of the deck with frequencies of running vibration.

At the same time the design features of the cargo decks, determined by the designation (large span, limited number of pillars and significant mass) are such that the relative stiffness of these members is low and there is the real danger that their main oscillation frequencies may be in the range of the frequencies of overall running vibration. In this case the dynamic coefficients for ship decks may be approximately 10-12, which may lead to the appearance of resonance amplitudes on the order of 1.0-1.2 mm with the permissible oscillation amplitudes of the hull (0.1 mm with blade frequency).

Because of this, the designers were faced with two main problems to provide permissible levels of local vibration:

--to investigate the oscillation characteristics of large-span planking secured by pillars and to develop the corresponding calculating scheme;

--to develop a method of determining the main oscillation frequencies of large-span cargo decks.

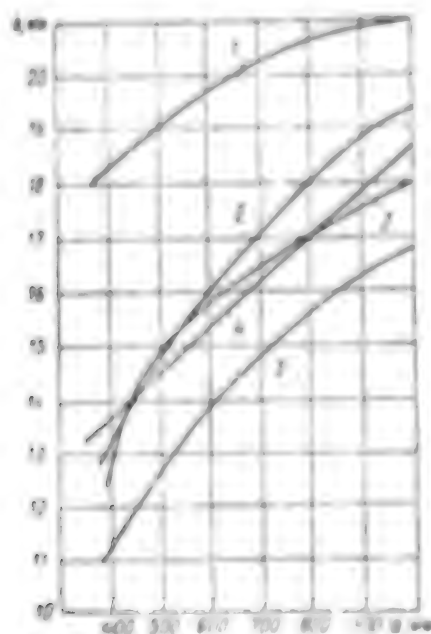


Figure 1. Effect of Variation of Spacing (l) on Thickness of Deck Planking (t) From Rules of Different Classification Societies: 1--American Office of Shipping; 2--Veritas Office; 3--German Lloyds; 4--Norwegian Veritas; 5--Lloyds Register

The investigations carried out under the supervision of V. I. Polyakov made it possible to establish that the main structural member which determines stiffness and consequently the main oscillation frequencies of cargo decks is the beam resting on a pillar. Longitudinal couplings provide joint operation of the planking field and may be assumed as "hanging" on the beams when determining the main frequencies. These propositions made it possible to construct a scheme for calculating the main oscillation frequency of the cargo deck which takes into account the presence of notches, nonidentical connection assemblies of the beams and the side planking and the pliability of the pillars. Moreover, a method of calculating the main oscillation frequencies of cargo decks was worked out. The basis of the method is the static-analytical version of the energy method. The characteristic feature of the given version is that the static forces which simulate the effect of inertial forces on the system during oscillations of the system according to the considered view rather than the shape of the oscillations are controlled when determining the oscillation frequency of the system. Extensive investigations of vibration of decks and other structures during operational voyages are planned for more detailed study of this problem.

From the viewpoint of strength, the weakest link in perception of the load transmitted by wheeled equipment is the attaching stiffness ribs and the deck planking. Determination of the dimensions of the longitudinal stiffening rib profile and planking thicknesses capable of receiving the load of lift trucks was preceded by careful study of the characteristics of transfer of forces by the wheels of lift trucks of different type, analysis of possible overloads when moving along planking with depressions, during braking and during hoisting and lowering of cargo. It should be noted that the requirements of foreign classification societies on the dimensions of the deck stiffening ribs are based on reception of concentrated forces by the ribs. The use of fork lifts with six wheels on the main axle on a ship required consideration of the finite dimensions of the supporting group of wheels and also the ratio of the distance between the axles and the span of the longitudinal stiffening rib.

The problem of designation of the thickness of the cargo decks, ramps and planking of the middle bottom in the region of the holds occupied a special place in the complex of problems on providing reliability and optimum metal consumption of the hull structures of the ship "Kapitan Smirnov." The fact is that the mass of cargo decks comprises a significant part of that of the empty ship (approximately 40 percent), of which more than half goes to planking in the region of the cargo compartments and correct designation of its thickness largely determines the economic characteristics of the ship.

The wheeled equipment used for cargo handling of a ship is capable of transporting cargo of large mass and significantly loads the deck couplings. The effect of the load is aggravated by the small contact area through which the forces are transmitted to the plates. The specifics of the problem included the fact that when determining the deck thickness by methods adopted for

ships of traditional classes, their values were exaggerated. Analysis of the requirements of foreign classification societies on the thickness of cargo deck planking of ships with ro/ro showed that the values of these thicknesses differ significantly from each other and there is no unified approach in derivation of the calculating functions (Figure 3).



Figure 4. Diagram of Upper Deck Planking: 1--pillars; 2--carling in center line plane; 3--carling; 4--longitudinal stiffening rib; 5--frame beam in pillar plane; 6--frame beam

Investigations of the work of plates due to the effect of large concentrated loads, carried out under the supervision of L. M. Helen'kiy, made it possible to formulate the main principles for regulating the strength of cargo deck planking of ships with horizontal cargo handling. These principles were based on the permissibility of plastic deformations, in real consideration of residual deflections and an estimate of their effect on the supporting capacity of the deck plates. Normalization proceeds in this case from the condition that the increasing residual deflections during the entire operating period do not exceed the norms established by defect regulations (with regard to the inevitable increase of the dynamic load coefficient from wheeled equipment due to the increasing unevenness of the planking).

Theoretical and experimental investigations of the accumulation of residual deflections were made with regard to the multiple nature of the effect of external loads on the plates. It was established that multiple loading of a plate by the same load may result in an increase (accumulation) of residual deflections only with a significant operating time of the ship when the appearance of significant changes can be anticipated in the residual stress field of the plate, occurring during first loading. At the same time the value of the residual deflections with accumulation of them should not be exceeded during operation and with any number of loads of given intensity.

These deflections may occur in a plate only toward the end of the ship's operating life; therefore, existing standards for damage detection may be used to limit them, i.e., the requirement can be advanced that it was unnecessary during the entire service life of the ship to repair the deck planking due to the residual deflections appearing in them. Thus, by providing adequate reliability with regard to concepts of an operational and economic nature when selecting planking thickness, the thickness of cargo decks was reduced to 16 mm, which permitted a reduction of the mass of the ship hull by approximately 900 tons.

The requirements of maximum convenience in cargo operations led to the need to use beams of identical and minimum possible height for deck planking. Optimization calculations were made for this purpose and also to reduce the mass of the coverings. Since the main supporting couplings of decks are the carlings in the center line plane, reinforced frame beams, intermediate carlings and frame beams (Figure 4), the purpose of the calculations was to determine the position of the intermediate carlings at which the stress state of all couplings was approximately identical and their height with the band did not exceed 500 mm for the middle deck and 600 mm for the remaining decks. Due to the refined calculations, the mass of the cargo decks was reduced by 60 tons compared to the initially developed designs.

Due to the absence of transverse bulkheads on the greater part of the ship length, the thrust responses of the side planking acting in the deck plane and also the components of the weight and inertial forces during side heeling cause transverse movements of the decks which lead to alignment deformations and additional stresses in the side couplings. Reinforcement of the side planking was required to reduce horizontal displacements of the decks, which was carried out by installing deep frames in the pillar plane and by using the ventilation channels passing along the side of the walls as supporting couplings. This permitted an increase of the strength of deck coverings by linking the reinforced frame beams (one of the main supporting couplings), a reduction of metal consumption and an increase of the volume of the cargo spaces.

Thus, the theoretical and experimental scientific research work made it possible to create a ship design, economical from the viewpoint of metal consumption, which meets operating requirements.

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STRUCTURAL AND TECHNOLOGICAL FEATURES OF THE HULL OF A RO/RO SHIP

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[Article by T. I. Bystrova, I. K. Ivanitskiy, V. V. Pusyrenko and Ye. G. Yassiyevich]

[Text] The large masses of hull designs, the complexity of the hull lines of the "Kapitan Smirnov" and the numerous attachments of the points of installing cargo (containers, vehicles and so on) and of cable guy blocks of movable platforms require the implementation of a number of measures to provide technological effectiveness of designs, to reduce the construction deadlines and to reduce laboriousness.

Increasing the number of surface sections, assembly and welding of which can be done on mechanized lines, occupies an important place in providing the technological effectiveness of ship hull construction. To solve this problem, the abovewater part of the hull is formed from sections of simplified shape and all the decks of the main hull and superstructures have no camber and sheer. The implemented measures made it possible to use up to 75 per cent flat sections in the volume (Figure 1).

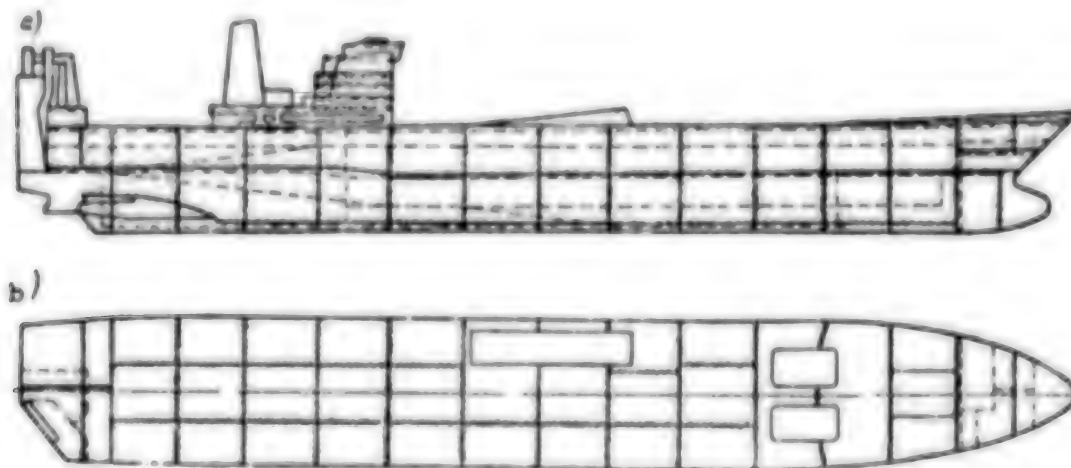


Figure 1. Diagram of Division of Ship Hull Into Sections: a--side view; b--upper deck

Containers, equipment and other cargo are secured on the ship by means of special container pockets, recesses for cranking cable and chain tighteners and backs. The total number of welded parts for securing cargo on a ship comprises more than 3,500 units. All these parts have attachments which provide normal operation of them. The aliquant dimensions of containers to the distances between longitudinal and transverse beams of the main deck planking generates a variety of versions of arrangement of container recesses with respect to the deck planking (longitudinal beams, deck beams and carlings) and as a result significant differences in the designs of attachments for recesses requiring strength calculations.

All possible cases of arrangement with respect to the planking couplings were considered when calculating the strength of attachments for three types of container recesses--single-, two- and four-seat--to standardize attachments for container recesses and to simplify the issue of detail plans. A limited number of types of attachments for each type of container recesses was worked out on the basis of this analysis and the areas of application of one or another type of attachments were determined as a function of the arrangement of the recess (Figure 2). As a result, the time of issuing the working documentation on the hull was significantly reduced and uniformity of the types of attachments was achieved.

The number of types was reduced by separating the deck into zones in which the recesses are arranged identically. A specific number of optimum attachments was worked out for each zone by the number of original versions of recess orientation with respect to the planking beams. These zones for two-seat recesses are shown in Figure 2, a and typical attachments are shown in Figure 2, b. Similar standardization was also carried out for other types of container recesses.

A great deal of attention was devoted in development of attachments for containers and securing recesses to reducing their volume, which led to an advantage in the metal consumption of structures and especially in the laboriousness of manufacturing them. This was mainly achieved as a result of reviewing the policy barred from foreign practice of installing container recesses at the points where the reinforcing beams intersect. Taking into account the stiffness of the container and the fact that the force of its weight is transmitted through four angular fittings and also taking into account the design of the recesses and the tolerances on manufacture of hull sections, it was assumed possible to install the recess on one reinforcing beam, which reduced the volume of the reinforcements and made them more technologically effective and less laborious.

Since the distance between the container recesses have rigid tolerances and the recesses themselves are installed on finished structures, the provision of accuracy in executing these operations occupies an important position in solving the problem of reducing the laboriousness of installing the recesses and reinforcements for them. For this purpose, the containers are arranged so that the recesses under each of them are located within one

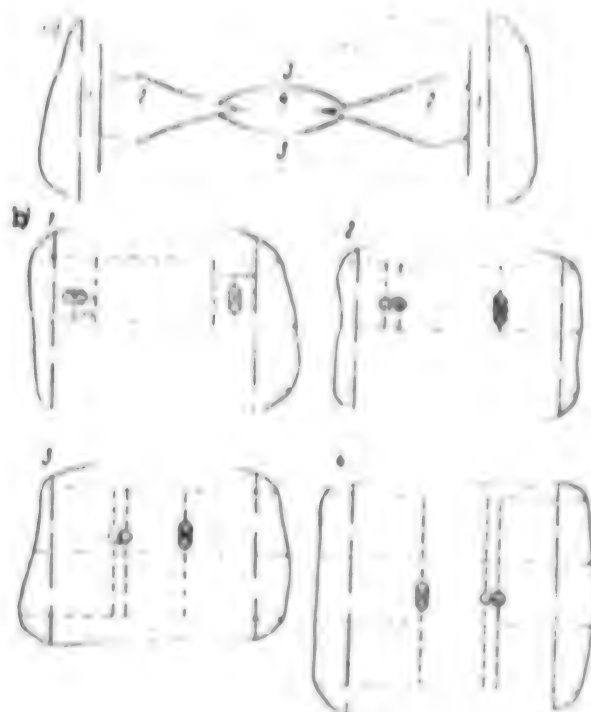


Figure 2. Diagram of Layout of Zones (a) and Attachments for Two Versions of Arrangement of the Container Seat in Corresponding Zones (b)

section, while the installation joints are located between containers. It becomes possible in this case to install the container recesses directly during manufacture of the section. This in turn requires a significant increase in the skill of manufacturing the hull structures, high precision of manufacturing the sections and a sequence of assembly and welding of the hull which would provide a reduction of deck irregularities and installation of all four container supports in the same horizontal plane.

A movable platform located between the main and middle decks and consisting of ten separate sections is provided for ship transport of automobiles. Each section of the platform is raised and lowered on cables by means of hydraulic jacks. The cable run for only one section of the platform is accomplished by using approximately 15 vertical and horizontal blocks. The low height of the deck planking (500 mm), within which the blocks with foundations must be located, and the significant dimensions of the blocks themselves caused significant difficulties in developing the foundations under the blocks.

The given accuracy in assembly of the hoisting device determined the need for final installation of the blocks only in platform and deck sections finished and placed on the ship. Leading in the cables is usually related to moving the blocks, which in turn required either development of the foundation with supporting surface of corresponding length or total refinishing of

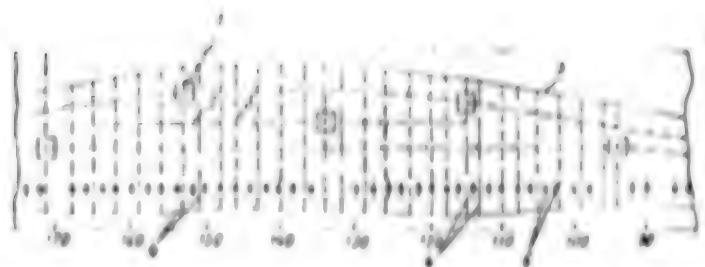


Figure 3. Layout of Keel Blocks When Placing the Ship in the Dock:
1--pages; 2--stringers; 3--floors; 4--floors in pillar
plane; 5--line of abutment of second bottom; 6--keel blocks

it. Large supporting surfaces and the low height of the foundation (up to 120 mm) determined the practically part by part assembly of the foundation directly on the ship but in this case the individual parts could not be welded with high quality and from both sides, which is necessary under conditions of dynamic loading of the structure. In most cases refinishing included development of a new foundation in the second version. Both versions led to an unjustified increase of laboriousness and metal expenditures.

It was decided to reject the foundations for moving the blocks during installation, to reduce laboriousness and metal consumption and to increase the technological effectiveness, which led however to an increase in the height of the block casing attached to the supporting couplings of the deck by short stiffening ribs. The following sequence of block installation was provided, which provides obvious advantages:

- the block is attached by temporary welds directly to the deck planking;

- a wire is strung between the blocks and the correctness of block installation is checked at minimum load;

- final welding of the blocks and the reinforcing ribs is completed.

The specific features of the hull structure required development of versions of placing the ship in the dock. The usual calculating scheme used when docking traditional ships was unacceptable for ro/ro ships due to:

- the high pliancy of the bottom planking in the region of the cargo hold;

- joint work of the bottom and decks combined into a unified system by pillars located in the centerline plane;

- sharp formations of the ship in the underwater part;

- the small contact area of the ship with the keel way;



Figure 4. Schematic Calculating Diagram of Non-Bulkhead Section of Hull in Placing Ship in Dock: 1--beams which replace the keel block group; 2--beams which replace the cages; 3--transverse bulkhead; 4--half-stiffness beams which replace the keelblock group; 5--beams which replace the ordinary floor group; 6--floors in the pillar plane; 7--half-stiffness beam of hull

--the large aft and forward overhangs.

Placing the ship in drydock on a single keel way and side cages was considered (Figure 3). The problem of taking into account the final stiffness of the bottom, the joint work of the bottom and deck planking joined by pillars and displacement of the size with respect to the keel way was posed in calculation.

Solution of the three-dimensional problem by using the finite element method, which permits all features of the ship to be taken into account, was the most precise. However, the large volume of input information and the complexity of controlling it and processing the results causes serious difficulties with respect to the spatial model. For simplification, the problem was divided into three steps:

--determination of the total pliancy of the decks;

--determination of the reactions of the docking device with regard to the stiffness of the bottom and decks;

--checking the strength of the ship hull.

A calculating scheme in which the ship hull was represented by two beams of variable stiffness, resting on elastic supports created by the keel blocks and cages, was used to solve the postulated problem. The total stiffness of the beams was equal to the stiffness of the ship (Figure 4). Planking limited in length by the transverse bulkheads on frames 77 and 171 and in length by the inner side was introduced into the calculating scheme in the region of the cargo hold. The distance of the shape of the bottom planking from rectangular was simulated by introduction of additional rods into the scheme. The cages and keelblocks were taken into account by means of equivalent beams of corresponding stiffness.

The decks were introduced into the calculating scheme to estimate the joint work of the bottom and deck planking when placing the ship on the keel way. For simplification, the decks were replaced in the scheme by individual beams whose pliancy is equivalent to that of the pack of decks at points where pillars are installed. This substitution is valid due to the sharp decrease in the value of the deck efficiency upon transition from the point of application of forces (one of the pillars) to the adjacent pillar, since the main supporting couplings of the decks are reinforced frame beams in the pillar plane in the given case, while the carlings only slightly load the adjacent frame beams.

The overall stiffness of the deck planking is comparable to the bottom stiffness and disregarding it in the calculation leads to reduced values of the keelblock reactions in the region of the cargo hold. The total pliancy of the deck planking was determined on a computer according to a special program.

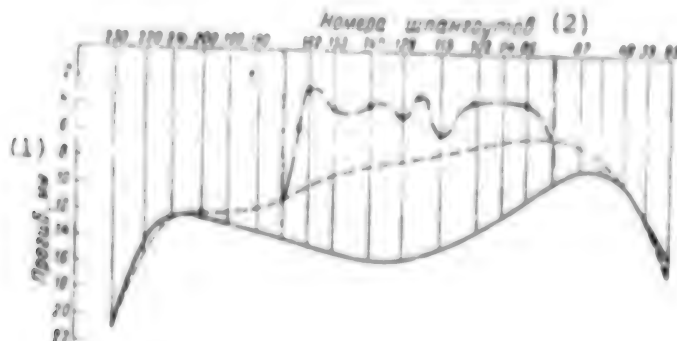


Figure 5. Bending-Moment Curves of Ship Hull: — --deflection curve of ship sides with regard to bottom pliancy; --- --deflection curve of ship (traditional scheme); -.- --deflection curve of ship sides;--transverse bulkheads

Key:

1. Deflection, mm

2. Numbers of frames

The bending-moment curves of the ship hull with regard to bottom pliancy, found upon realization of the described calculating scheme, are given in Figure 5. The deflections calculated by the traditional scheme of placing the ship in the dock when the ship hull is considered as a beam of variable stiffness lying on an elastic base treated by the keelblocks, are presented for comparison. It is obvious from the figure that the deflection curve of the ship in the traditional scheme of placing it in the region of the cargo hold has ordinates approximately one-half as much than those determined with regard to the ship pliancy.

Analysis of the distribution of the keelblock reactions with regard to bottom pliancy showed that the ship hull is most heavily loaded in the regions

of the ends. The reactions drop sharply in the nonbulkhead section of the ship and local peaks of reactive forces are noted at points of pillar installation. The keelblock reactions in the region of the hold are one-half those with regard to bottom pliancy than in the case of their determination for the ship as for beams of variable stiffness.

It is obvious on the example of calculating placement in the dock, carried out with respect to the "Kapitan Smirnov," that consideration of the structural features of these ships--pliancy of the bottom and deck planking--significantly alters the pattern of distribution of keelblock reactions. The calculation made it possible to reject introduction of the proposed reinforcements at points of pillar location and near transverse bulkheads. [8144/1010-6521]

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OCEAN AND RIVER

THE STATE BADGE OF QUALITY TO MANUAL STEERING GEAR

Leningrad SUDOSTROYENIYE in Russian No 3, 1980 p 21

[Article]

[Text] Manual steering gear of type RRSh and RRShS with steering cable run are installed on ships, ship lifeboats and barges. RRSh-1 and RRSh-2 steering cable gear are non-self-braking; gear of the first modification is attached to the vertical support and that of the second is attached to a horizontal support. RRShS manual steering gear is self-braking.



Manual Steering Gear of Type RRSh

Main Characteristics of Steering Gear

Наименование характеристики (1)	Марка шестов (2)		
	РРШ-1	РРШ-2	РРШ-3
(3) Крутящий момент на валу, Н·м	200	200	1870
Длительность переключения с 35° одного борта на 30° другого на полном переднем ходу, с (4)	3,7	0,4	29,6
Угол переключения, град (5)	70		
Ресурс до капитального ремонта, ч (6)	20000		

Key:

1. Name of characteristic
2. Mark of gear
3. Torque on stock, N·m
4. Length of turning from 35° of one side to 30° of other side at full forward speed, seconds
5. Angles of helm, deg
6. Service life to major overhaul, hr

A complex of measures which permits an increase of the service life of the products to major overhaul and the mean cycles between repair was carried out during preparation of РРШ-1, РРШ-2 and РРШ-3 steering gear for certification for higher category of quality; design changes were introduced to simplify maintenance of the gear.

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MECHANIZATION OF CARGO OPERATIONS ABOARD A RO/RO SHIP

Leningrad SUDOSTROYENIYE in Russian No 3, 1980 pp 22-23

(Article by V. M. Antonenko (deceased) and V. V. Koshelev)

[Text] The problem of intensification of maritime shipments of general cargo is now being solved by reducing the anchoring time of ships for cargo operations as a result of using new process flow diagrams and also due to an increase of running speed.

The use of new process flow diagrams which provide maximum acceleration of ship cargo-handling processes and also the successes achieved in development of small highly maneuverable lift trucks made it possible to develop ocean-going universal ro/ro ships. Provision of a continuous loading cycle--transport of packaged cargo by means of a lift truck from the warehouse directly onto the cargo deck without intermediate "crane" operations and the possibility of loading wheeled equipment under its own power--permits reduction by a factor of 4-5, the length of cargo operations compared to the vertical method of cargo operations on universal dry-cargo ships equipped with crane cargo equipment.

Roll on-roll off cargo handling permits loading and unloading a dry-cargo ship with capacity of 10,000-15,000 tons within not less than 2-3 days. Thus, the new method of cargo operations provides intensity of cargo work achievable only on container carriers with cellular construction of holds, although compared to the latter, the labor expenditures are significant for control of the lift trucks and securing of the cargo. The advantage is the universality of new ships with respect to the type of cargo, since transport of any general cargo and wheeled equipment becomes possible in addition to international containers. The calculated amount of cargo* delivered by the

*Calculated in the percentage of the total volumes of transported types of cargo by reinforced locations, by the specific loaded volumes of this cargo, with regard to the maximum use of the cargo capacity of the ship, deck areas and also the maneuvering and design capabilities of the ship cargo handling facilities.



Figure 1. Transport of a 6.1-Meter Container on the Upper Deck by a TD2512 Lift Truck Equipped With Side Grab

"Kapitan Smirnov" comprises: 33.9 containers, 36.9 packets, 24.6 items of machinery and equipment and 4.6 items of wheeled equipment. The time required to load the indicated nomenclature of cargo by shipboard lift trucks comprises approximately 40 hours.

Highly productive and maneuverable lift trucks carry out cargo operations on a ship. The set of cargo handling equipment is selected according to the nomenclature of the cargo transported by the ship. The following equipment is provided on the pilot ship: eight forklifts of three sizes with capacity of 25, 16 and 4 tons, four lift trucks designed for cargo of 25 and 13.5 tons, two truck container carriers which transport 12.2-meter containers with mass up to 30.5 tons. The cargo-handling equipment is supplied by the Valmet Company.

Forklifts are designed to carry out cargo operations with different cargoes, including those with 6.1-meter international size containers. The lift trucks stack the containers in two levels and can also tow trailers and semitrailers. Container work can be carried out both with forks and with grabs for the containers (Figure 1). A truck container carrier can also stack containers in two levels.

All the lift trucks are equipped with catalytic converters for diesel exhaust gases. The normal operation of the lift trucks is provided with ship heeling up to 3°. The lift truck DVS (internal combustion engine) are heated from the ship electrical system for starting during the cold season.



Figure 2. Testing the Sloping Stern Ramp

A repair station supplied with the necessary equipment is provided on the ship for repairing the lift trucks. An inspection hole is equipped in the stern part of the main deck to inspect the rolling assemblies of the lift trucks. The lift trucks are secured for the voyage by means of fast-grab chain tightening devices. Containers, packed equipment and cargo are transported by the lift trucks on skids through the stern ramp (Figure 2) to the main deck, from which they are then moved along inclined ramps. The slope of the stern ramp, altered as a function of the ship draft, and the slope of the ramps and also the dimensions of the door spans, bulkhead doors and the width of the passage part of these structures provide passage of all types of shipboard lift trucks (Figure 1) and also of practically all domestically produced trucks, trailers, semitrailers, vans and tractors. The ramp is installed in the stern of the ship at an angle of 40° to the centerline plane on the right side and has a passage width of seven meters. Cargo operations are carried out with the pier height with respect to the deck on which the ramp is installed within the range from -2.2 to $+4.5$ meters on the dock, separated from the side of the ship at a distance of 0.1 to 1.5 meters. The maximum permissible angle of inclination of the



Figure 3. Lift Truck on Ramp

ramp is 9° . The machinery which services the ramp automatically maintains its level with respect to the pier during variation of the ship's draft and provides loading on the pier from the ramp with cargo of not more than 19 kN/m^2 .

To facilitate the process of container loading, the locations of installing them on the decks are indicated by a distinguishing color. Progressive methods of securing the transported containers and wheeled equipment by using fast-grab chain tightening devices to reduce the time of loosening the cargo on the ship. All the parts for securing the transported cargo are stored in special cabinets near the locations of their use. Easy and safe access on the cover of the containers of the first and second levels during attachment of them is provided by means of movable platform ladders and light portable ladders. Thus, the ship is supplied with powerful highly productive loading equipment which provides high intensity of cargo operations.



Figure 4. Securing of TD2512 Lift Truck for the Voyage



Figure 5. Attachment of Truck Container Carriers for Voyage

The experience of operating the pilot gas turbine ship "Kapitan Smirnov" confirmed the correctness of the decisions made in the project with respect to selecting the loading equipment and the schemes for loading the ship.
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A VENTILATION SYSTEM FOR CARGO SPACES

Leningrad SUDOSTROYENIYE in Russian No 3, 1980 pp 24-25

[Article by M. A. Melezhik and A. Ya. Dovgan']

[Text] The main tasks of the ventilation systems for the cargo spaces of ro/ro ships are maintenance of permissible concentrations of noxious gas exhausts formed during operation of lift trucks and other wheeled equipment in the holds during cargo operations, providing an explosive-safe atmosphere in the cargo spaces during transport of wheeled equipment with filled fuel tanks and providing the conservation of the transported general cargo. To meet these requirements, productivity of the artificial ventilation system was designed on the basis of operating conditions, as a function of which it should:

- absorb noxious gas exhausts, the volume of which is determined by the amount of wheeled equipment operating simultaneously in the cargo space which in turn depends on the cargo handling time, when conducting cargo operations;

- provide not less than six air exchanges per hour according to the USSR Rules of Registry when transporting wheeled equipment with fuel-filled tanks;

- maintain a threefold exchange of air per hour according to normative documents when transporting general cargo.

The productivity of the ventilation system for the cargo spaces required to absorb noxious exhaust gases comprises 1,458,000 m³/hr for ships of the "Kapitan Smirnov" class. Delivery of this amount of air requires a well-organized air distribution system in the spaces. However, development of a complex branched air duct system was impossible since this system would significantly hinder the cargo spaces of the ship.

Based on analysis of the advantages and disadvantages of different methods of air distribution in the cargo spaces of ro/ro ships, a combined system of ventilation with longitudinal delivery and transverse exhausting of air

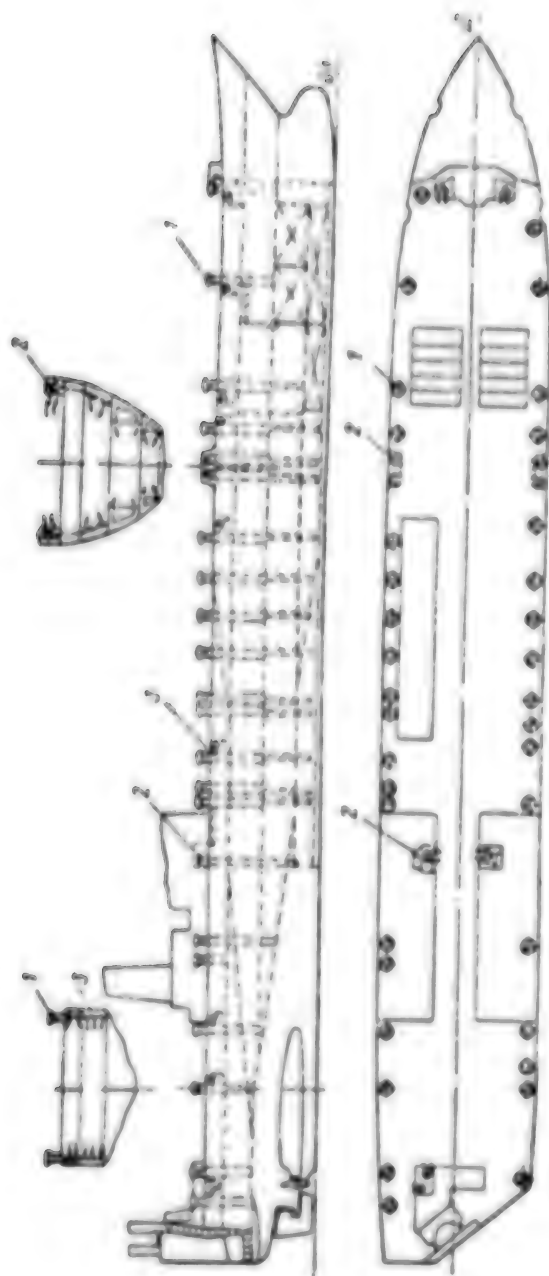


Figure 1. Layout of Ventilation System Components on Ship: 1--mushroom cap; 2--centrifugal blower; 3--air channel

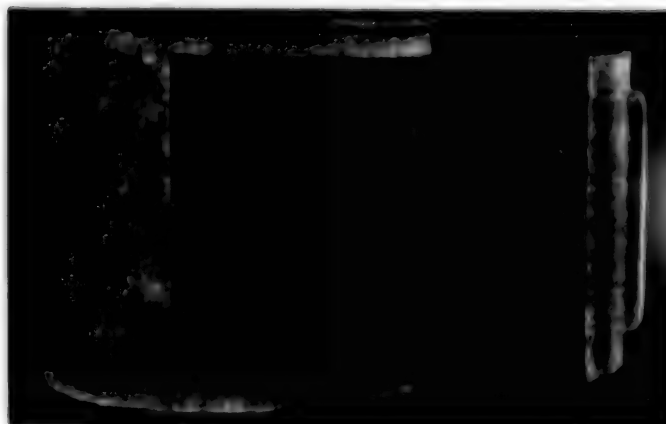


Figure 2. Axial Explosion-Safe Blower

during cargo operations and with a transverse delivery-exhaust scheme during transport of cargo (Figure 1) was used. The incoming air in the amount of approximately $600,000 \text{ m}^3/\text{hr}$ is delivered to the cargo spaces by 10 centrifugal blowers of mark 400/16 TsSU-44B, installed in special enclosures on the upper deck. Exhausting is provided by 36 axial explosion-safe electric blowers of mark 400/6.3 OSO-4.4 with delivery of $40,000 \text{ m}^3/\text{hr}$ each and pressure head of 620 Pa (Figure 2), which are installed on the upper deck. Air is taken in and exhausted through mushroom-like caps (Figure 3). Remote control of the ventilation caps and exhaust ports installed in the ventilation channels of the upper tweendecks and also monitoring of the blower and fittings operation are provided.

The air ducts are made in the form of vertical channels welded to the sides in whose upper and lower parts there are openings covered by screens. The ratio of the areas of the openings is selected so that approximately 60 percent of the total amount of air is removed from the lower part of the hold. The holds are ventilated during transport of cargo only by axial blowers. In this case the blowers on the right side deliver the air and those on the left side remove it. The number of blowers operating simultaneously is determined by the necessary degree of air exchange in the cargo spaces as a function of the type of cargo transported.

Model tests which wholly confirmed the correctness of the adopted design solutions and which made it possible to establish a number of recommendations for manufacture and testing of the system on the ship were carried out to check the correctness of selecting the air distribution scheme.

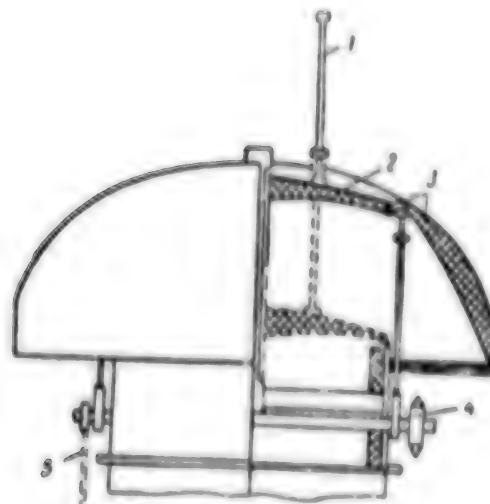


Figure 3. Upper Part of Mushroom-Shaped Blower Cap: 1--plate position indicator; 2--plate; 3--insulation; 4--hydraulic drives; 5--manual drive

Much attention was devoted during design of the ventilation system for the cargo spaces of the "Kapitan Smirnov" to problems of improving its servicing conditions during operation and also to conditions of habitation. Besides developing remote control and monitoring devices for the operation of the system, investigations directed toward noise reduction were carried out. As a result, a noise-absorbing insulating coating was applied in the through part of the mushroom-shaped caps, axial blowers and in the upper part of the channels. The possibility of replacing the electric motor together with the rotor is provided to facilitate maintenance of the axial blowers during operation. This operation is carried out through a hinged cover in the blower housing.

Tests on the system onboard the "Kapitan Smirnov" confirmed its efficiency, ease of monitoring and control of operation and the sufficiently low general noise level, which indicates its high operational qualities.
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OCEAN AND RIVER

STATE BADGE OF QUALITY FOR RADIO-FREQUENCY COUPLINGS

Leningrad SUDOSTROYENIYE in Russian No 3, 1980 p 25

[Article]

[Text] Radio-frequency couplings are designed for end disconnection and connection of radio-frequency cables to equipment installed on ships and barges of all classes and designations and also at shore radio centers.

Depending on their designation, the couplings are divided into connecting--for non-release splicing of the ends of cables, release--for release joining of the ends of cables, transition--for splicing radio-frequency cables of different diameters--and apparatus--for connecting cables to apparatus.

A number of design and technological improvements has been introduced into the couplings since the first certification, namely: a highly stable conducting coating was used, joining the ends of cables connected to the couplings was converted from a bayonet connection to splicing by soldering, the housings of some couplings are manufactured by a progressive method--casting in a chill mold--and the quality of the galvanic coatings of the coupling parts is checked by a special measuring device.

These improvements permitted the expansion of the working range of the couplings to 60 MHz, to increase the service life of the couplings up to 15 years and to reduce the laboriousness of manufacture by an average of 3.6 percent.

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THE STATE BADGE OF QUALITY FOR A HYDROSTATIC RELEASE DEVICE

Leningrad SUDOSTROYENIYE in Russian No 3, 1980 p 25

[Article]

[Text] The hydrostatic release device is used for manual or automatic release of the lifeboat lashings; in the case of automatic release, the device is triggered due to the effect of hydrostatic pressure upon submergence by 1.5-3.5 meters. The device is efficient in tropical and arctic sea conditions in the temperature range from -30 to +66°C, the permissible force on the release link is 6 kN, the permissible angle of inclination of the device in any plane is up to 50° as a function of the direction of tightening of the lashing and the mass of the device is 4.7 kg.

The design of the device ensures reliable securing of the lifeboats under stormy conditions, manual release of the lashing (including that during icing) and installation in the operating position after triggering without using any tools. Compared to foreign analogs, the device is distinguished by closed arrangement of the release members and fewer protruding parts.
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MARINE GAS TURBINE POWER PLANT

Leningrad SUDOSTROYENIYE in Russian No 3 1980 pp 26-30

[Article by A. Ya. Markov]

[Text] A number of additional requirements are placed on the power plant of ro/ro ships, the main ones of which are:

--the large unit power required to reach high speeds;

--the possibility of operating on heavy, comparatively inexpensive grades of fuel to increase the economic indicators of ship operation;

--the relatively small height dimensions to provide formation of the passage part required in the ship hull for transport traffic during cargo operations.

Gas turbine power plants with heat utilization circuit meet these requirements most fully.

A gas turbine propulsion plant (GTU), consisting of two main gas turbine units (GGTA), each operating on its own fixed pitch screw, was adopted on the two-screw ship "Kapitan Smirnov." The total output provides the ship with a speed of approximately 25 knots. Each unit consists of an automated reversible gas turbine engine (GTD), reducer, heat utilization circuit (TUK) and their auxiliary mechanisms and devices.

The TUK contains automated utility boiler and steam turbine (PT) with condenser. The utility boiler of type KUP3100 is made with thinned pipes. Because of this, its overall dimensions were minimum with the required steam productivity. The productivity of the boiler is 2,250 kg/hr for saturated steam and 24,000 kg/hr for superheated steam.

The automated PT of type PTU-2 and the condenser are serviced by ejectors, a reduction-cool device and condensate pump. In the maximum mode, the steam consumption to the turbine comprises 24,000 kg/hr at pressure of approximately 1.5 MPa and temperature of 310°C.

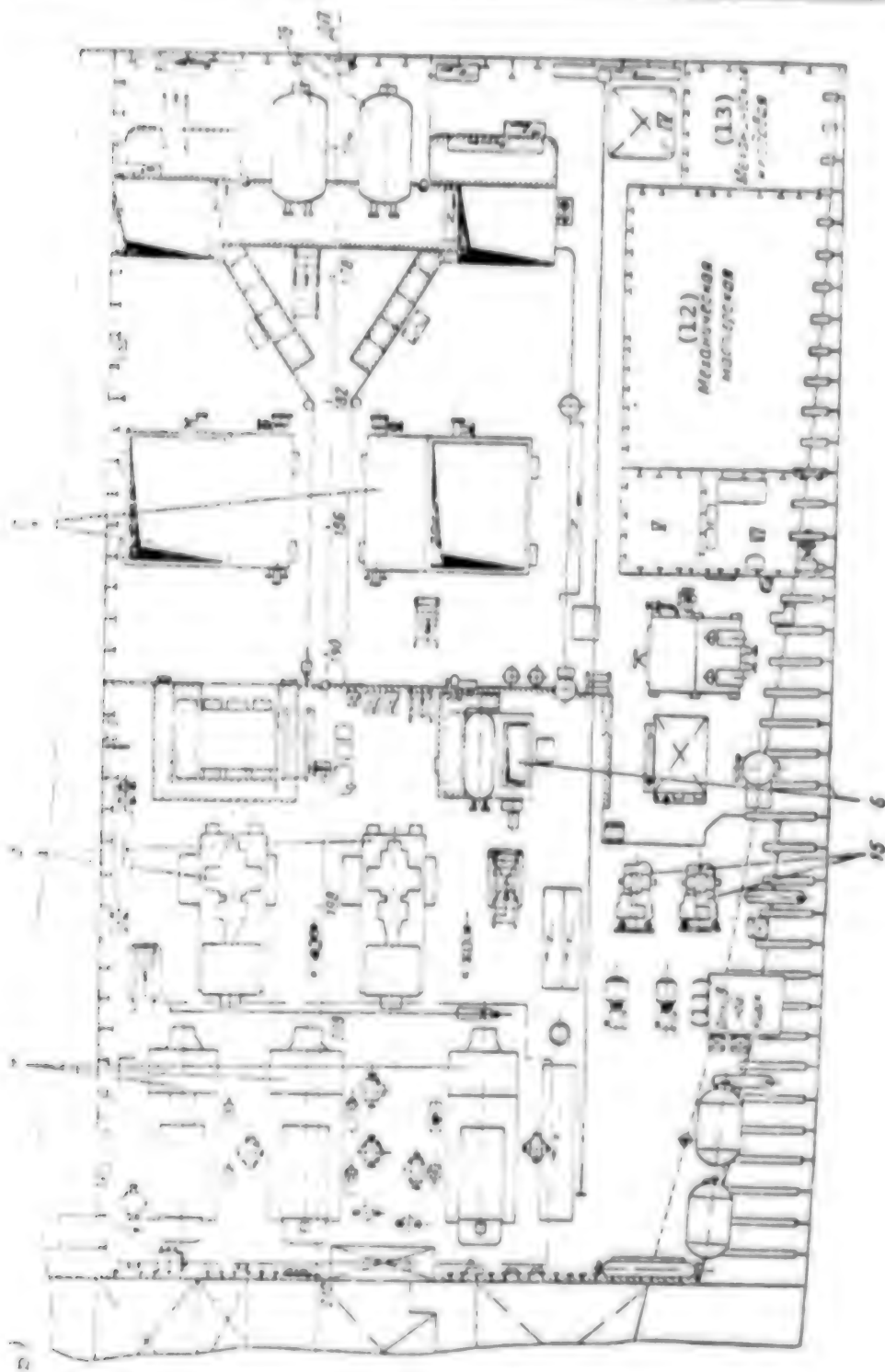


Figure 2 (Continued).
 separation unit; 13--outside water pump unit; 14--freshwater pump unit; 15--electric compressor station; 16--hold water separator; 17--muffler-spark arrester; 18--ballast-drain pump block; 19--utility boiler steam separator; I--spent reduction gear oil tank; II--waste-circulating oil tanks of reduction gears; III--spent diesel generator oil tank; IV--cutout for loading machinery;
 [Continued on following page]

The propulsion plant provides maximum forward-running power of 16,780 kW (without bleeding the steam to the turbogenerator and the ship's needs) at 128 rpm on the output flange of the reduction gear. The nominal power is equal to 14,560 kW (with bleeding of steam to the turbogenerator and for the ship's needs) at 128 rpm on the output flange of the reduction gear.

The power plant permits operation of a single unit per screw with non-operating second GGTA and braked or freely rotating shafting. Operation of the GGTA of one side to its own screw is also possible, whereas the steam generated in its utility boiler will be fed to the PT of the second unit to rotate the other screw.

With remote control from the TaPU, instructions are issued:

- to the GTC and TUR control systems for remote switching of the mechanisms and devices contained in the GGTA;
- to the GTC start, false start, cold idling and stop control systems;
- to the TUR automatic apparatus for starting and stopping (with and without the steam turbine);
- to change the output of the GGTA;
- to process the reverse and "stop-screw" programs with signals to the automated control and protection system (SAUZ);
- to switch from diesel to gas turbine fuel and so on.

The control station switch is located on the control console in the TaPU. Simultaneous control of the GTC from both stations is excluded.

Remote control of each GGTA from the TaPU is accomplished by means of the mode control lever and the reverse lever combined with the machine telegraph transponder.

The power plant is prepared for operation from the local stations, while the GTC is started from the TaPU. Approximately half of the nominal power from the TaPU can switch on the steam turbine during forward running of the ship with GGTA output. It can be switched off and stopped remotely and also automatically in the following cases:

- upon conversion of the GGTA to the maneuvering mode;
- during reverse from forward to reverse;
- upon conversion of the GGTA to the "stop-screw" mode;
- in case the GGTA output decreases below the level adequate for efficient operation of the steam turbine (50 percent of nominal).

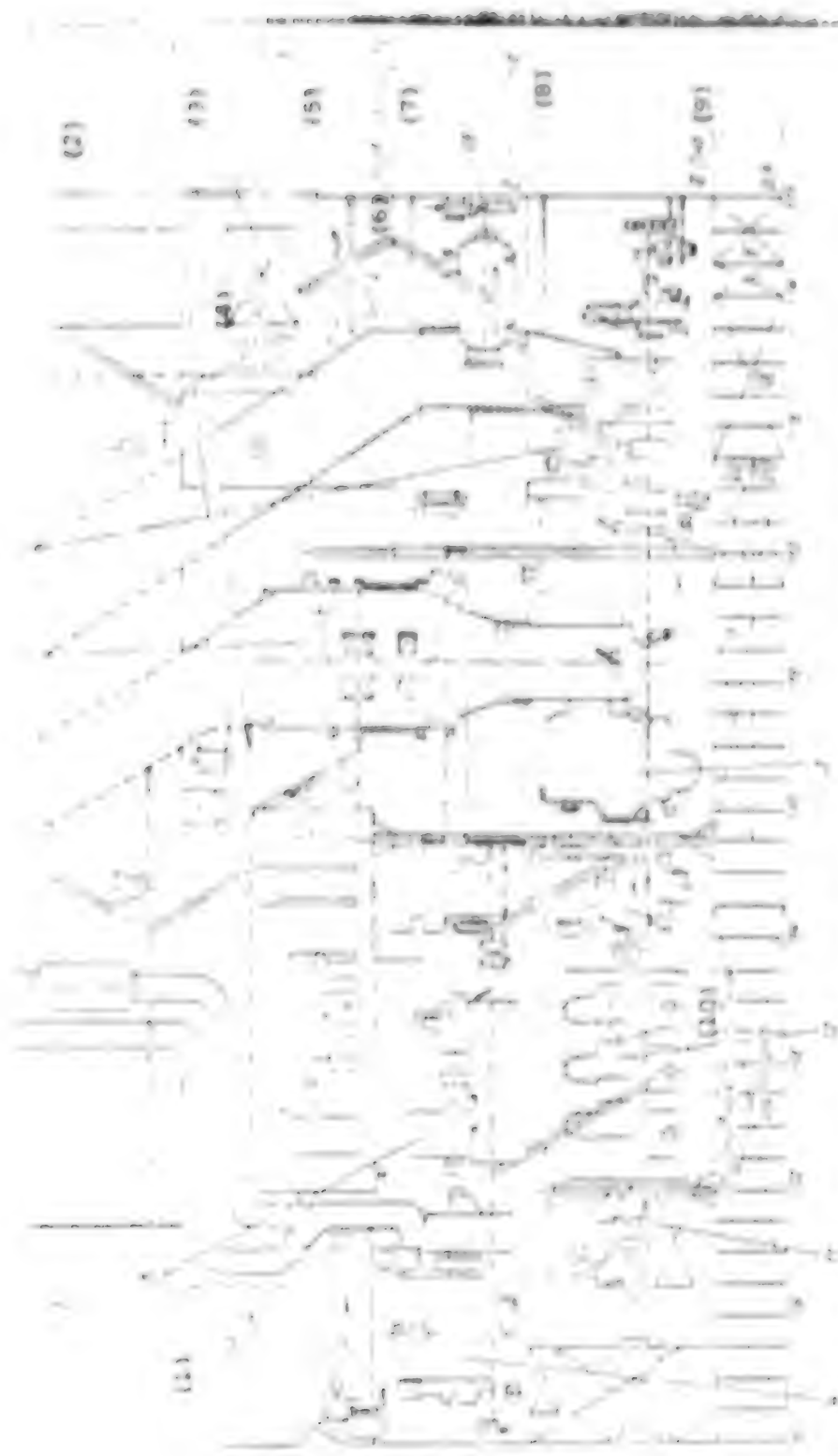


Figure 2. Arrangement of Mechanisms and Equipment in Engine Room:
 a--view toward left side; b--layout of first platform; c--cross-section of ship;
 1--gas turbine engine; 2--steam turbine; 3--reduction gear; 4--DGA1000/750 diesel generator; 5--
 TALLING turbogenerator; 6--auxiliary boiler; 7--utility boiler; 8--oil pump unit; 9--gas turbine
 fuel pump unit; 10--diesel fuel pump unit; 11--diesel fuel separation unit; 12--gas turbine fuel
 (Continued on following page)

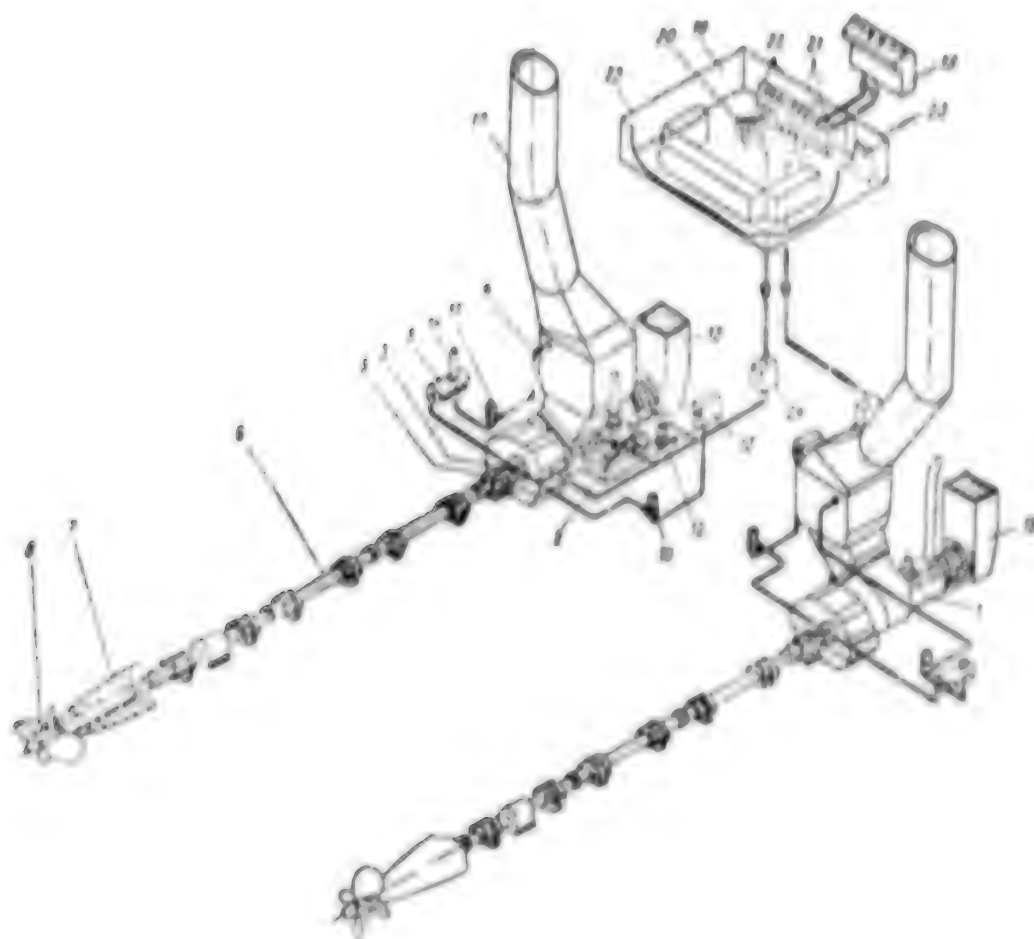


Figure 1. Propulsion Plant Configuration of Ship "Kapitan Smirnov": 1--D159 gas turbine engine; 2--PTU-2 steam turbine; 3--reducer; 4--KUP3100 utility boiler; 5--thrust bearing; 6--shafting; 7--deadwood device with Simplex packing; 8--screw; 9--steam separator; 10--delivery pump; 11--circulating pump; 12--condensate pump; 13--heat box; 14--pipes for delivery of steam to utility boiler for super heating; 15--pipes for steam delivery to steam turbine; 16--air-intake shaft; 17--gas exhaust pipe; 18--central control console; 19--control console in wheelhouse; 20--control console in TsPU; 21--Shipka centralized monitoring system panels; 22--panels of automated remote control system of Izhora electric power plant; 23--panels of control complex for Naroch' general ship systems; 24--GTH control station (SAUZ); 25--main distributing frame--GRShch

The diagram of a marine propulsion plant is shown in Figure 1. To increase economy, the steam from the TUX is delivered to two utility turbo-generators and also for the ship's needs.

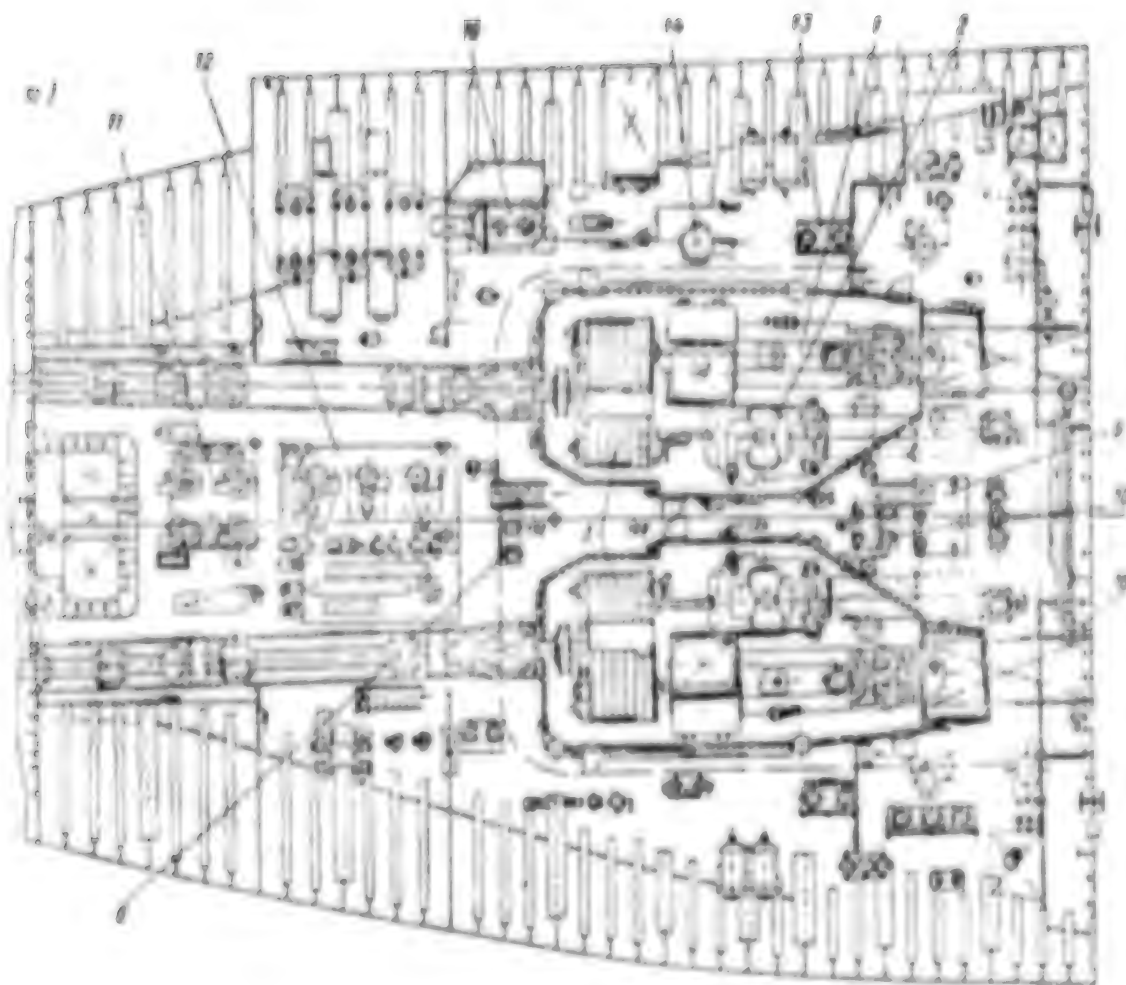


Figure 2 (Continued).

V--hopper pressurisation room; VI--fuel and oil analysis laboratory; VII--collecting tank for fuel and oil leaks; VIII--bilgewater tank; IX--boiler water tank; X--ballast passage; XI--oil reserve tank for reduction gear; XII--oil additive reserve tank.

Key:

- | | |
|-----------------------|-----------------------------|
| 1. Electrician's shop | 4. GTU oil reserve tank |
| 2. Upper deck | 5. Second platform |
| 3. Middle deck | 6. Spare parts machine room |

(Key continued on following page)

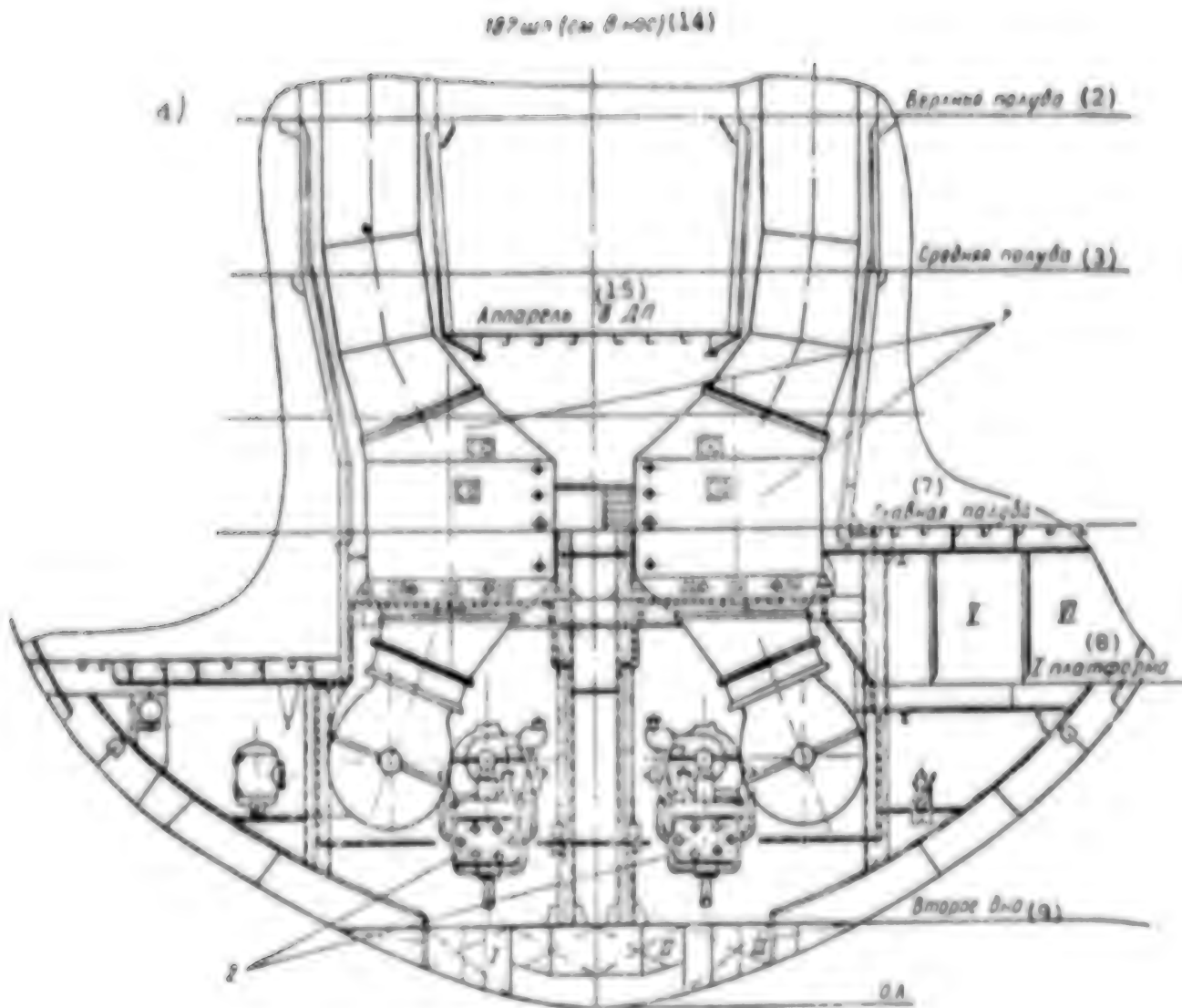


Figure 2 (Concluded).

Key (Continued from preceding page):

- | | |
|------------------------|------------------------------------|
| 7. Main deck | 12. Machine room |
| 8. First platform | 13. Machine store |
| 9. Second bottom | 14. Frame 187 (looking toward bow) |
| 10. Fuel tank overflow | 15. Ramp to centerline plane |
| 11. Casting box | |

The volume of automation ensures control of the power plant by a single watch officer in the TsPU without a constant watch in the MKO (Engine and boiler room), which is adequate for assignment of automation symbol A2 of the USSR Registry in the ship class symbol. Besides the two GGTA control systems described above, the following is also provided on the ship:

- an SAUE for the GTD and PT of each side;
- centralized automatic monitoring of the parameters of the power plant and DAU by mechanisms servicing the propulsion plant;
- remote control of general ship systems;
- remote-automated control of the electric power plant;
- DAU by compressed air compressors;
- automatic control and regulation of the auxiliary boiler;
- automation of the fuel and oil separators and so on.

The first operational voyages showed high maneuvering qualities of the ship. Very successful solution of the operating capability of the GTD of one side and of the steam turbine of the other side should be noted. A speed of 18-20 knots was achieved in this case, which permits variation of the ship speed as a function of the transported cargo with a significant fuel saving and service life of the GGTA.
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THE MAIN GAS TURBINE PLANT OF THE "KAPITAN SMIRNOV"

Leningrad SUDOSTROYENIYE in Russian No 3, 1980 pp 30-32

[Article by V. T. Lisov]

[Text] The power plant (EU) of the "Kapitan Smirnov" uses two M25 main gas turbine units (GGTA) (Figure 1). Each unit consists of a DI59 gas turbine engine (GTD), KUP3100 utility boiler (UK), steam turbine (PT) with condenser, ejector and reduction-cooling device (ROU), a PO25 reducer common to the GTD and PT and auxiliary equipment. The steam generated by the utility boiler is used in the steam turbine, the TGU1000 utility turbogenerator turbine and for general ship needs.

Main Characteristics of M25 GGTA (Figure 1)

	In maximum mode (without bleed- ing steam to the TG)	At nominal mode (with bleeding of steam to the TG and for ship needs)
Forward running output, kW	18,390	17,280
Including, kW:		
GTD	14,120	14,120
steam turbine	4,270	3,160
Specific fuel consumption (in GGTA) not more than, g/(kW·hr)	238	256
Rotational frequency of output reduc- tion gear flange, rpm	130	128
Maximum reverse output, kW	--	5,740

The indicated characteristics of the GGTA are provided under standard operating conditions.

Bleeding of 6,000 kg/hr of superheated steam with pressure up to 1.2 MPa and temperature of 310°C to the turbogenerator and 2,250 kg/hr of saturated steam with pressure up to 1.2 MPa for ship needs is provided in the GGTA.

The GGTA operates over the entire range of operating modes from idle to nominal power without forbidden zones and also permits prolonged operation (within the service life) without the TUK (with "dry" boiler) at output up to 14,120 kW.

The GTD is started automatically from the central console and the possibility of manual correction of fuel delivery is provided during starting. Starting is accomplished by two electric starters with power supply from the ship electrical system through a rectifier. In this case the starters provide no more than three sequential starts and two cold idlings or false starts with interval of not less than 120 seconds between switching on. Subsequent starts are authorized after total natural cooling of the starters to 60°C. The normal starting time of the engine from the cold state to idle is not more than two minutes. Continuous operation in idle up to 60 minutes is permitted. The time for going to full load of the GGTA from the cold state is not more than one hour. The GGTA provides reverse from four forward to full reverse and vice versa and also setting of the "stop-screw" mode. Reverse is accomplished by changing the direction of turbine rotation of the screw by redistributing the gas flow by the reverse members; the steam turbine is automatically cut off from the reduction gear while the steam from the boiler is discharged to the condenser through the reduction-cooling device. The total rotational frequency of the high-pressure compressor is achieved after the beginning of the maneuver within not more than 120 seconds when reversing from full forward to full reverse or vice versa.

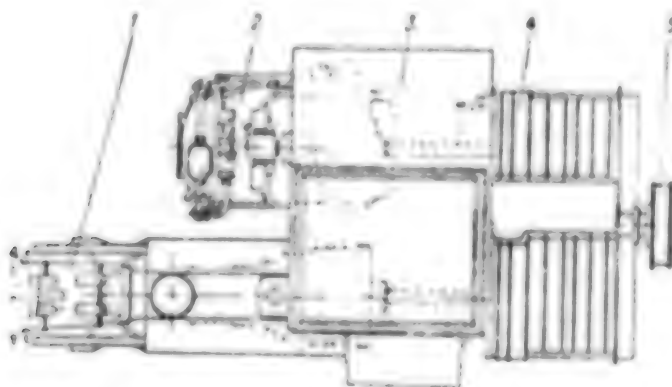


Figure 1. GGTA of Left Side: 1--GTD; 2--utility steam turbine; 3--steam boilers; 4--reduction gear; 5--coupling

The GTD is a direct-flow, two-stage, axial type and consists of series-arranged axial turbines--two-stage high- and low-pressure (TVS and TND) and

a reversible three-stage screw turbine (TV). The unit also contains a circular-tubular combustion chamber (the housing of which contains 10 heat tubes with nozzles) and two series-installed axial compressors--a seven-stage low- and nine-stage high-pressure (KND and KVD).

The high-pressure turbine sets the KVD in motion and the low-pressure turbine rotates the KND. The torque from the TV is transmitted through flexible couplings and the shaft to the reduction gear. The housings of the compressors, combustion chamber and turbines are connected in series to each other by vertical flanges into a single block. The input internal and external caps are located at the input to the KND, the gas bleeder is located behind the screw turbine and the GTD is secured by six supports to the frame. The hot part of the housing is covered by a heat-insulating covering.

The reducer is three-stage and has two branches to which the GRD and PT are connected (see Figure 1). The branch of the gas turbine engine is split in the first stage of the reduction gear and is divided into four flows in the second stage. The branch of the steam turbine is split in the second stage. The GTD is connected to the reduction gear through flexible couplings and the shaft. The steam turbine is connected to the reduction gear by a friction-disk coupling, which is switched off automatically if the PT is taken out of action.

The torque from the GTD and PT is transmitted through two branches through six drive gears to a single driven wheel connected to the shaft by a flexible coupling which protects the reduction gear against axial oscillations of the screw shaft. All the gears and wheels rotate on sliding bearings. The reduction gear housing is welded-steel, ribbed and made of sheet steel and the bearing supports are cast. The detachable housing consists of upper and lower halves and has upper side, bow and stern covers.

The GTD has a number of systems which serve to ensure normal functioning of it without trouble-free operation.

The utility boiler is located above the gas bleed of the GTD and is connected to it by means of a compensator. The steam productivity of the boiler is 24 tons of steam per hour at pressure of 1.2 MPa. The boiler is a water-tube type with multiple forced circulation and is rectangular in cross-section. It consists of the following main assemblies: an economizer, evaporating surface and steam superheater between which are located support beams for attaching the tubular packets. The coils of the boiler tubular packets are made of shinned pipes. The thins are formed by a helically wound tape welded to the pipe. The presence of a double skin ensures the necessary tightness of the boiler and permits reduction of the insulating thickness. The gas-air ejector located behind the boiler sucks in cooling air sequentially under the heat-insulating skin of the GTD, the gas bleed skin and in the boiler space between the skin. Four horizontal supports and footings are provided to secure the boiler. A water-washing device is provided for periodic washing of the heating surfaces of the boiler.

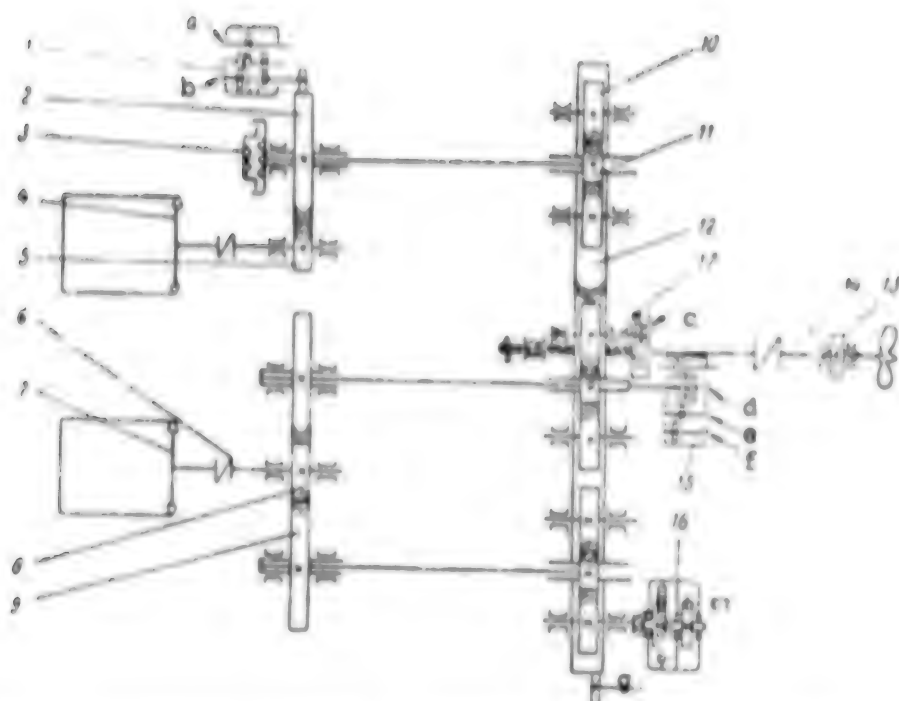


Figure 2. Kinematic Diagram of Reduction Gear: 1, 15 and 17--drive boxes; 2 and 9--driven gears; 3--friction-cam coupling; 4--steam utility turbine of screw; 5, 8 and 11--drive gears; 6--torsion shaft; 7--gas turbine of screw; 10--intermediate gear; 12--driven gear wheels; 13--main thrust bearing; 14--flexible coupling; 16--shaft-rotating device; a and d--to tachometer sensor; b and e--to synchronizer sensor; c--to reversograph sensor; f--to centrifugal oil-unit sensor; g--to hanging oil unit

The boiler also includes a horizontal steam separator with fittings, which simultaneously serves as the TUK water tank.

The condensation type steam turbine has a welded-cast body in which the rotor bearings are located. There is a flange on the top cover to install the fast-closing steam inlet valve (BZK) and a flange for attachment of the ROU is welded to the exhaust connecting pipe. The turbine exhaust pipe is connected to the condenser by means of a compensator.

The steam turbine rotor is a double-beat with packing discs and consists of a single rotor with two velocity stages and seven pressure stages. The thrust bearing is two-sided with self-adjusting thrust segments filled with a babbitt and the thrust flange is made as a single hole with the rotor shaft. The support bearings have steel babbitt-filled bushings.

The surface type, two-stroke condenser is the frame on which the steam turbine and auxiliary equipment are located.

The thermal layout and operating principle of the GGTA. Atmospheric air is compressed by a two-stage compressor and combustion of the fuel occurs at constant pressure in the GTD combustion chamber. The formed gas is expanded sequentially in the TVD, TND and TV and the power from the TV is transmitted to the screw through the reduction gear. After the GTD, gas enters the utility boiler at temperature of 390°C (gas flow rate of 91.8 kg/s) in which the gas temperature is reduced to 179°C due to heat transfer. The feed water with temperature of 40°C is directed from the hot well by means of a feed pump to the separator of the steam boiler. The multiple forced circulation pump delivers water sequentially to the economizer and to the evaporation part of the boiler. The steam-water mixture then enters the steam separator from which the wet steam is directed to the steam heater and through the main cutoff valve (GSK) to the BZK of the steam turbine. The BZK is opened automatically at vapor pressure of 390 kPa . Steam is delivered through it to the main ejector. When a vacuum of $49\text{--}59\text{ kPa}$ is reached in the condensor, the BZK opens, occupying the no-load position, and to rotational frequency of the steam turbine begins to increase. When synchronous rotational frequency is reached, the PT is automatically connected to the reduction gear.

The surplus steam is removed at this time through the BCU to the exhaust pipe of the PT to the condensor. After the PT warms up in the no-load mode for 12-15 minutes, the BZK opens up completely and the PT gains the established load. There is continuous scavenging of the steam pipeline through the automatic scavenging valves until the BZK opens up completely.

The TUK is put into operation when feedwater is delivered to the boiler and in any operating mode of the GTD (hot starting) and with inoperative GTD (cold starting).

The main ejector creates a vacuum in the condensor at vapor pressure of 390 kPa and above. The PT is switched on when the vapor pressure is not below the indicated pressure. This vapor pressure can be achieved at GTD operating modes from 25 to 50 percent of nominal power as a function of the outside air temperature. Taking into account that economy of the unit has no significance during maneuvering in port and that the PT is switched off at reverse rotational frequency, the "port" and "sea" modes are distinguished. The TUK of the power plant is switched off during operation in the "port" mode and it is switched on in the "sea" mode.

Diesel fuel of marks DS or "I" according to GOST 4749-73 and also fuel according to GOST 305-73 "L" is used in the GTD for starting, stopping and during reverses. Gas-turbine fuel with introduction of special anticorrosion additives can be used for prolonged operation at operational modes.

Oil according to GOST 10289-62 is used in lubrication of the GTD and turbine oil of mark Tp-46 (according to GOST 9972-74) is used for the reduction gear and the steam turbine. The average hourly oil consumption for the GTD does not exceed 2 kg/hr and that for the reduction gear and the steam turbine does not exceed 1 kg/hr .

Mass (kg) and Overall Dimensions of GGTA

Mass of the unit in the operating state, kg	149,000 + 2,000
Including:	
GTD with frame, gas bleeder, housings, spring, oil tank and electrical equipment	19,000
reduction gear with coupling	55,000
utility boiler with DAU fittings, separator and TUK electrical equipment	45,000
steam turbine part of power plant with coupling and spring	22,700
Maximum width, mm	5,155
Height with boiler (without exhaust device), mm	10,875
Height with exhaust device, mm	12,525
Total length from inlet device of GTD to exhaust flange of reduction gear, mm	12,245

The operating life of the unit has been established at 100,000 hours and that of the main GTD assemblies until major overhaul under plant conditions comprises 25,000 hours when the GTD is operating at 85 percent of service life in nominal mode. One major overhaul of the reduction gear is provided during its service life, after running-in of 50,000 hours. The service life of the GGTA is 25 years, that of the GTD is 12.5 years, dismantling of the GTD and inspection of individual assemblies of the unit is made once every four years from the time the ship is turned over for operation.

The GGTA has a high degree of repairability. Thus, any suspended part of the GTD (the drive box, fuel and oil pump and so on) can be replaced under operating conditions within 2-3 hours. The possibility of total replacement of the GTD by a reserve available on the ship is provided.

The first results of ship operation confirm the main characteristics established in the GGTA and the prospects for using them on ships of the maritime fleet.
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AUTOMATED MACHINERY CONTROL SYSTEM ON THE GAS-TURBINE SHIP 'KAPITAN SMIRNOV'

Leningrad SUDOSTROYENIYE in Russian No 3, 1980 pp 33-36

[Article by V. A. Andrezen, V. V. Voytetskiy and Yu. I. Kolkunov]

[Text] One of the main trends in development of ships of the maritime transport fleet is introduction of automation and centralization of the machinery (TS) control processes on them. The main criterion for evaluating the degree of automation became in this case the level of organization of TS maintenance. The "Tropik" TS control systems installed on the gas turbine ship provides operation of the EU [Electrical apparatus] without a constant watch in the MKO, which is characterized by the automation symbol A2 of the USSR Registry in the symbol of the ship class.

Wide standardization of many assemblies was carried out in developing the means of automation by using the structural set and the functional blocks of the well-known "Zaliv" complex and standard developments of panels.

The "Tropik" complex includes the following automated remote control systems: the "Raskat" for the gas turbine plant (DAU GTU), the "Izhora-6" for the electric power plant (DAU EEU) and the "Naroch'-6" for the ship systems (DAU SS).

Moreover, an automated centralized monitoring system (TsAK) of type "Shipka U-7" is provided.

The "Tropik" complex is designed to operate for 20 years with mean cycles between repair of four years. This is provided by the use of components of increased reliability and by reducing their load coefficients. Redundancy of the most important control channels and monitoring of malfunctions are used to achieve high reliability of the systems and the "standby" mode is used as the main one during operation of the components.

The hierarchical structure of the GTU and SS control systems is three-stage and that for the DAU EEU is two-stage (Figure 1). Minimum overall dimensions, mass and length of the communications lines are provided with this construction of the systems; the logic part of the system is located under the most favorable microclimate conditions in the TsPU.

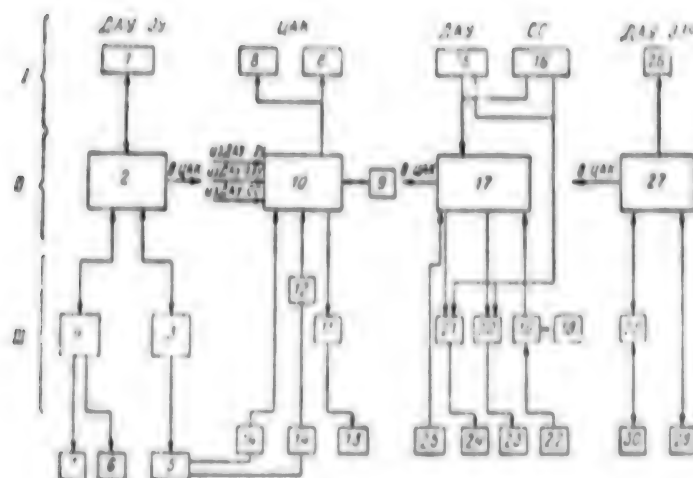


Figure 1. Block Diagrams of "Tropik" Control Systems: 1 and 2--GTU control console from the wheelhouse and the TsPU, respectively; 3--actuating mechanisms; 4--device of intermediate relays; 5--gas turbine unit; 6--heat utilization circuit; 7--auxiliary mechanisms; 8--generalized signalling blocks; 9--rundown recording device; 10--information display devices; 11--intermediate relay devices; 12--disconnect devices; 13--auxiliary mechanisms; 14--sensors and signalling devices; 15--SS control console from wheelhouse; 16--SS control and signalling panel at the dispatcher's station; 17--SS control and signalling panel in the TsPU; 18--pneumatic power supply block; 19--pneumatic-electric converter blocks; 20--machinery control device; 21--intermediate relay device; 22--armature position signalling devices; 23--pumps; 24--armature; 25--parameter signalling devices; 26--signal boards on GTU control console from wheelhouse; 27--EEU control panels from TsPU; 28--automatic devices; 29--automatons on GRShch; 30--diesel and turbogenerators; I, II and III--degrees of hierarchy

Power is delivered to the systems from the AC ship supply system voltage of 127 and 220 V (50 Hz) and from rotary converters (220 V, 400 Hz) and also from a DC power system with voltage of 26 V from rectifiers and 24 V from a storage battery (to signal about failure of the power supply). When the main power supply sources fail, the reserve sources switch on automatically. When there is total power outage on the ship and when the emergency diesel generator is started, the control systems receive power from it (from the load busses not switched off) and automatically (or remotely) carry out programmed starting of the auxiliary machinery. Pneumatic power with pressure of 0.6 MPa is delivered for the "Raskat" and "Haroch'-6" systems.

One of the methods of increasing the operating efficiency of the systems is to use the principle of monitoring their malfunction. Automatic (for

continuously operating circuits and test monitoring carried out periodically are used in the systems. The location of the malfunction is determined with accuracy in a replaceable functional block. This reduces the time for search and correction of the malfunction. Individual and generalized luminous and audio signalling are used in the systems. The former is displayed on mini flow sheets and consoles while the latter is fed to the generalized signalling blocks. The condition of the TS is characterized by actuating, warning (noncritical) and emergency (critical) signalling. A unified algorithm for lighting up the critical and noncritical signals is used in this case.

The actuating signalling lamps burn with an even color:

- white when processing instructions (for example, on closing the armature);

- green when displaying the steady state of an object (for example, the signal on the closed-on position of the automaton).

The warning signalling gives with a yellow blinking light when the parameter deviates from the normal value. The light signal is stored and accompanied by audio display. The red blinking light of emergency signalling is switched on by the same algorithm. The blinking light and the audio signal give an acknowledgement (they are removed by the unblocking button), after which, if the parameter has not returned to normal, the display board burns with an even light until the normal value of the parameter is restored. Critical and noncritical signals, upon the appearance of which the operator must interfere in the control process, are delivered to the generalized signalling blocks. The generalized signalling blocks are located in the cabins of the machinists, mess, wheelhouse, officers' quarters and the captain's office.

The gas turbine plant is controlled by the "Basker" GAT GTU system, where- as the experience of developing similar systems established on the ship "Koris Butoma" could be used when designing the remaining systems, no similar analog was available for controlling the GTU. Therefore, an experimental model of the system was manufactured and it was tested on a bench with the experimental gas turbine unit (GTA).

It is known that the GTU as a control object has specific features. They include the need for slow acceleration due to the narrowness of the range of permissible operating modes at small loads, taking into account the effect of the outside air temperature on the permissible power when operating in the full load mode and modes close to it, monitoring a large number of parameters during starting, fulfilling complex time programs during control in maneuvering modes and providing additional fuel delivery during starting (in case of "sticking" of the turbocompressor).

The GTU of the ship "Kapitan Smirnov" also includes steam turbines and a large number of other control objects different in their characteristics.

The steam turbine is connected to the screw shaft only at specific output of the GTU.

The "Raskat" system is based mainly on electrical components, with the exception of the channel switching coupling for control from the wheelhouse (TR) to the central control station (TsPU), which is carried out pneumatically. The given system provides control of the GTU by means of a single lever with a machine telegraph scale for each side in the range from the lowest to full speed and also reverse and the "stop-screw" mode. Optimization of the reverse, acceleration and power drop programs is accomplished in this case. The programs for changing fuel delivery to the GTU when controlling the plant from the wheelhouse are shown in Figure 2.



Figure 2. Time programs provided by OMI GTU: 1--power gain according to "port" program (1.4 deg/s); 2--power gain according to "sea" program (0.5 deg/s); 3--power gain according to "port" program (1.4 deg/s); 4--power gain according to "sea" program (0.5 deg/s); 5--power gain until idle (0.5 deg/s); 6--emergency power gain during reverse (2-6 deg/s); 7--emergency power gain from "stop" button (6 deg/s); 8--power gain in low mode zone (0.5 deg/s); α_{in} --angle of rotation of actuating mechanism; *--time

The "Raskat" system has three control channels for performing the following operations: smooth changing of fuel delivery to the GTU; three-position switching of the reverse members ("forward motion," "stop-screw" and "reverse motion"); connection and disconnection of the steam turbine (ST). Control of the GTU is provided according to two programs: "port" and "sea."

The "port" program is designed to provide maximum maneuverability of the ship during porting. The ST is switched off in this case and the GTU operates on diesel fuel. Maximum operating economy of the power plant is provided upon switching to the "sea" program. Authorization to switch on the ST when the GTU reaches power of approximately 40 percent of nominal is

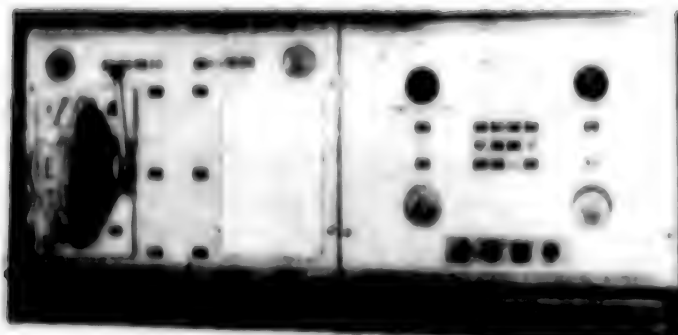


Figure 3. DAV GTU Console of "Raskat" system in Wheelhouse (Bench Model)

this case. The restriction diagram for full power varies as a function of the outside air temperature. The PT is switched off in the "sea" mode by the operator or automatically when instructions for reverse are transmitted.

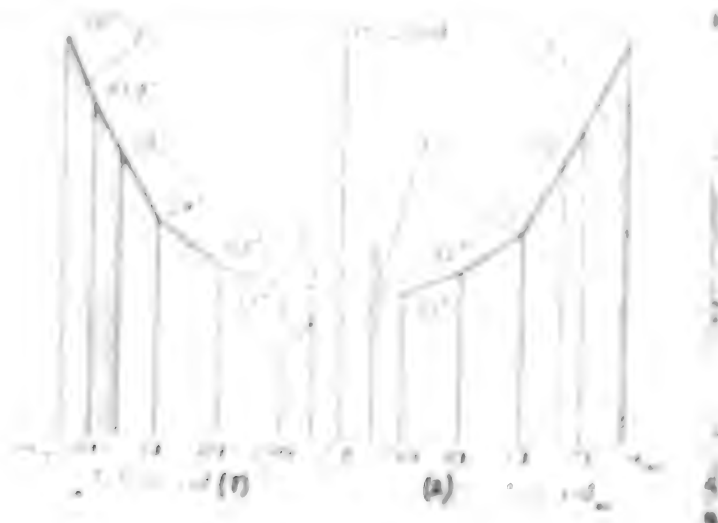


Figure 4. Static Characteristics of DAV GTU: 1--zone for regulation of "stop-screw" mode; 2--boundaries of operating zone during forward and reverse; α --angle of rotation of engine telegraph lever; S-V--"stop-screw"; SSK--slowest speed; MKH--low speed; MKH--medium speed; FKH--full speed

Key:

1. reverse

2. forward

All control from the wheelhouse (Figure 1) is accomplished by means of two members--the toggle switch for program selection and the engine telegraph lever which controls reverse and fuel delivery. During reverse, the command signal to change fuel delivery is transmitted after the engine telegraph lever is set to a new position. Power is automatically dropped only to the zone where reverse is authorized and entry of the GGTa to the given mode according to the corresponding program is provided after the reverse devices are switched. The static characteristics of the system are given in Figure 4. The restriction of the working zone which protects the power plant against overload with an increase of outside air temperature and also the permissible zone for regulation of turbocompressor output in the "stop-screw" mode are shown in it. Protection (except temperature and "overspeeding" of the GTD (and emergency stopping of the units are also accomplished if necessary from the console in the wheelhouse. Signalling lamps about the state of the GGTa of both sides are located on the panel of the console and the indicators of the screw tachometers, the indicators of the direction of rotation for the "stop-screw" mode and the instruments which show the position of the actuating mechanisms are also located there.

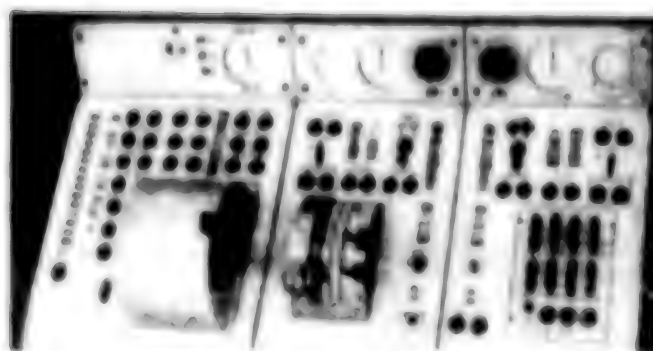


Figure 5. DNV GTV console of the "Paskat" system in the TaPU (Bench Model)

Fuel delivery to the engines is controlled from the TaPU by cable transmission. A reduction gear with gear ratio of $1 : 180$ is introduced in it to provide the necessary acceleration program. Emergency dumping of power and correction of fuel delivery during starting are performed by separate drive at $1 : 1$. The reverse members are controlled by a separate lever. The members for starting the main engine, switching on the heat utilization circuit and control of the auxiliary mechanisms of the DT with corresponding signalling about their condition are provided in the console in the

The engines are started and warmed up from the TAPU and control is then transferred to the wheel house in the "stop-screw" mode. The possibility of converting the GTU to gas-turbine fuel is provided from the console in the TAPU. Conversion to new fuel is accomplished when the power is not above 50 percent of nominal in the "sea" mode. In this case the fuel heating temperature should be within the range of 25-45°C. Conversion to diesel fuel is accomplished automatically when the GOTA power is reduced. The valves and pumps of the fuel system are controlled through the intermediate relay device. A number of signals are fed to the generalized signalling blocks (malfunction of the DAP, loss of power supply, emergency of the GTU and so on) to provide operation of the GTU without a watch. Part of the signals is also fed to the reversograph for recording.

Analysis of the characteristics of gas turbine ships of the "Euroliner" class shows that the single-value dependence between the position of the control levers in the wheelhouse and the rotational frequency of the screws during fixed fuel delivery is disrupted during prolonged operating modes. This is determined by the dependence of the GOTA output on the outside air temperature, clogging and salt build-up of the compressor, switching the heat utilization circuit on and off, the condition of the fuel and the dependence of the drag on the ship's draft and other factors. All these effects lead to the need to regulate fuel delivery to maintain a given motion of the ship as a function of operating conditions.

A promising trend for improving the DAP GTU system includes provision of automatic maintenance of the screw rotational frequency by means of a regulator. However, this regulator should correspond to a number of specific requirements. It should provide steady operating mode of the GOTA turbo-compressor in swell and high speed when performing maneuvers. The investigations showed that a screw rotational frequency regulator which generates a signal with time delay and with restriction on the value of the effect and connected as a corrector of the main signal transmitted from the wheelhouse to the actuating mechanism, most fully meets these requirements.

Let us consider the functioning of the remaining systems of the "Tronik" engines.

The subject of control for the "Izhora-6" system is the electric power plant, consisting of five generators with different primary motors--two utility turbogenerators (VTG) and three diesel generators (DG). With the presence of powerful users of electric power on the ship such as the steering gear, interlocking devices which permit these users to be connected only after the reserve DG are started are provided in the "Izhora-6" system. When the voltage on the CRSH bus drops to 80 percent of nominal and there is a malfunction, corresponding signalling generated to the panels and on the generalized signalling blocks is provided in the "Izhora-6" system. Signals on the operation of the VTG and DG are sent to the wheelhouse on the main engine control console. The VTG is switched on automatically and the reserve DG assumes the load during maneuvering if the GOTA power and vapor pressure decrease.



Figure 6. DAV EEM Malfunction Monitoring Section of "Izhora-6" System

The electrician's interference during operation of the electric power system is required only when it is put into operation for the initial operating mode (switching the first generator to the GRShch busses and selecting the reserve DG and also when starting the nonautomated turbogenerator). All the DG are supplied with an automatic starting and control system and are used as reserve systems. The UTS and DG are equipped with regulators which permit automatic power distribution during parallel operation of them. The "Izhora-6" system provides starting of the reserve DG when 90 percent of the nominal load in the operating generator is reached, automatic synchronization, load reception and distribution, protection of the generators against overload, protection of one of the phases against

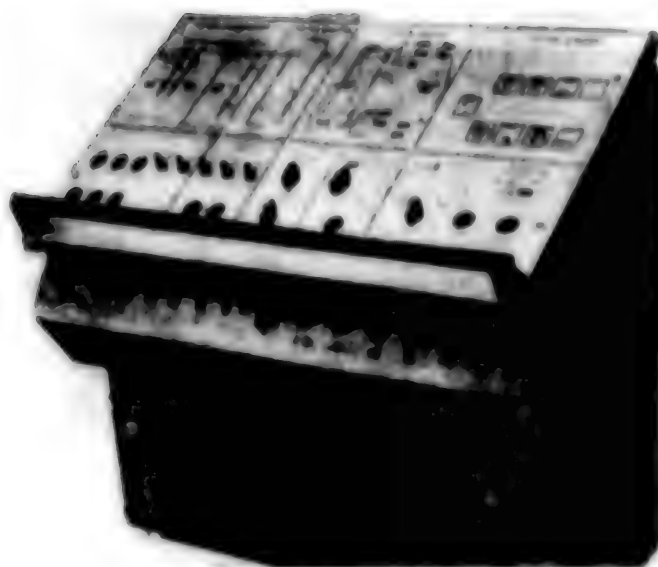


Figure 7. "Naroch'-6" Control Console of Ship Systems From Wheelhouse

opening during power supply from shore and other functions inherent to systems of the "Izhora" type.*

The control and signalling panel of the "Izhora-6" system is located in the TsPU and consists of the UTG and DG control sections and the system malfunction monitoring section (Figure 6).

The "Naroch'-6" SS control system provides control of eight shipboard systems: trim, lighting, fuel reception and pumping, heavy fuel heating in the tanks, firefighting water, heeling, sprinkling and hydraulics. The control, logic and information parts of the system are electrical. With regard to the fact that an armature with hydraulic and pneumatic drives and pneumatic signalling devices of the final positions is used in the indicated systems, the "Naroch'" system includes pneumoelectric converter blocks which transmit signals about opening and closing of the armature. The pneumatic power supply block is included in the system for supplying power to the pneumoelectric converter blocks.

* "SUHOETROYENIYE", No 8, 1977, pp 34-38; No 12, 1979, pp 25-27; No 12, 1979, pp 25-28.

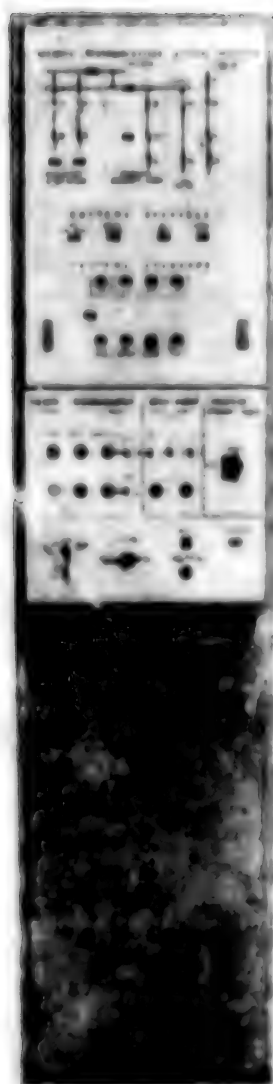


Figure 8. Control and Signalling Panel of "Naroch'-6" Ship Systems at the Dispatcher's Station

The pumps and valves are controlled from the ship system console in the wheelhouse (Figure 7) and signalling on the state of the firefighting and sprinkling systems is also accomplished from the wheelhouse. To determine the ship's metacentric height by heeling prior to departure on a voyage and to maintain heeling in the range of $\pm 2^\circ$ during loading, which is necessary

for normal operation of the lift trucks (carrying containers), the heeling system and also signalling on the operation of the pump, the position of the valves, the water level in the heeling tanks, heeling greater than 2° and 5° and so on are controlled from this console. Moreover, signalling on filling the bilgewater wells for the drainage system with decoding of the number of the well and also of a loss of electric power by the "Naroch'-6" system, a pressure drop in the hydraulic system and a fire in the engine room is also transmitted to this console. A control panel (Figure 8) from which the firefighting water and sprinkling systems are controlled and also automatic action on the heeling system (for straightening the ship during loading) and signalling on filling the wells of the drainage system are controlled, is installed at the dispatcher's station (DP) to control the hold and other ship systems during anchorage in port.

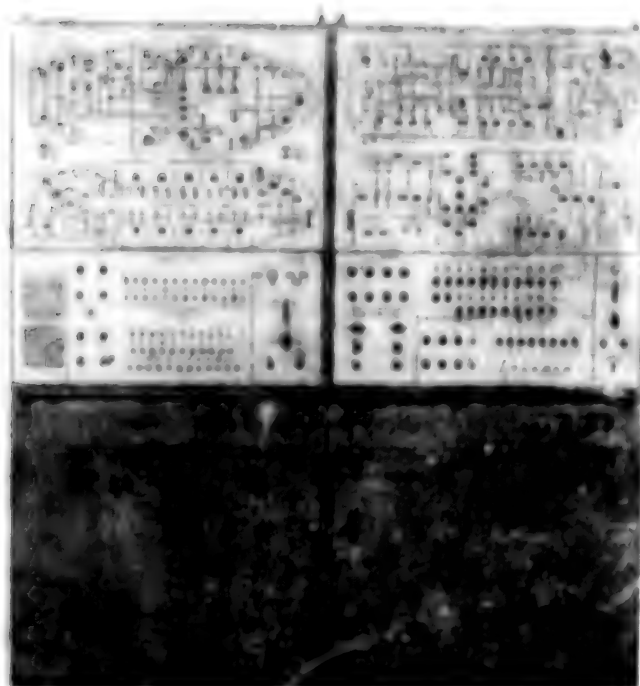


Figure 8. "Naroch'-6" Control and Signalling Panel of Mainboard Systems in the TsPC

Periodic control of all the systems with the exception of the heeling and sprinkling systems, is accomplished from the panel located in the TsPC

(Figure 9). Remote control of the pumps and armature of the systems is accomplished in this case. A light signal informs the operator on the operation of the pumps, the position of the valves, when the working medium reaches upper levels in the tank (with time delay) and the bilgewater wells, on excess of given temperatures of the gas turbine fuel in the tanks, pressure drop in the hydraulic system and so on. If the monitored wells in the drainage system become filled, if there is an overload of the firefighting pumps and a loss of power supply, a signal is transmitted through the centralized automated monitoring system to the generalized signalling display.

Number of Parameters Monitored by the "Shipka" System

Наименование операции контроля (1)	„Шипка У-6“ (2)	„Шипка У-7“ (3)
Сигнализация (4)	175	280
Цифровое измерение (5)	66	156
Регистрация выбега (6)	36	54

Key:

- | | |
|---------------------------------|-------------------------|
| 1. Name of monitoring operation | 4. Signalling |
| 2. "Shipka U-6" | 5. Digital measurement |
| 3. "Shipka U-7" | 6. Recording of rundown |

Centralized automated monitoring (TsAK) of machinery and also control of a number of auxiliary mechanisms is accomplished by the "Shipka U-7" system. Its main distinction from the other systems of the "Shipka" class includes the fact that it monitors a considerably greater number of parameters. Comparative data on the "Shipka" systems of two modifications are presented in the table. The "Shipka U-6" is designed to monitor the machinery of the single-shaft diesel ship "Boris Butoma." The apparatus of the "Shipka U-7" system is shown in Figure 10.

The design version of the apparatus of the "Tropik" systems meets aesthetic requirements on formulation of the interior of the control stations and takes into account the recommendations of ergonomics with respect to the arrangement of the control members and information display and also the norms of the USSR Registry in the part of the mechanical and climatic effects. The DAI GTU and SS consoles in the wheelhouse are made the same as the ship navigation consoles and resemble the lighting. The DAI console in the TsPU is sectional and provides control of the GTU by a single operator. Sections of the "Shipka U-7" TsAK system are joined to the angular sections of this console. The control and signalling panels of the "Izhora-6", "Haroch'-6" and "Shipka U-7" systems in the TsPU and also the panel of the "Haroch'-6" system at the dispatcher's station are made sectional from standard racks. The panels of the mimic flow sheets and the monitoring devices are located on the upper part of the panels and the control and

system malfunctioning monitoring members are located on the lower part. The logic part of the systems consists of functional blocks located in the consoles, panels and peripheral devices. The latter are made watertight and have a standardized design distinguished only by the number of rows of installed blocks. Aluminum-magnesium alloys are mainly used as the material for the system structures.

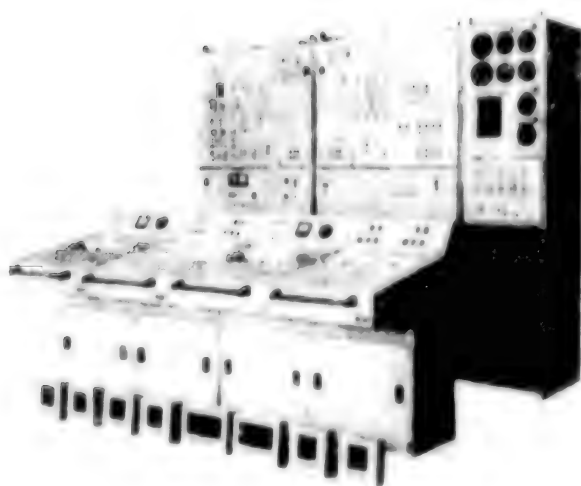


Figure 10. Apparatus of "Shipka U-7" System

The experience of turning over for operation previously installed automation systems on ships of the "Zoya Kosmodem'yanskaya" and "Boris Butoma" class was refined during design of the "Tropik" systems. The experience of adjustment and turnover of the systems on the manufacturing plants' benches showed that they correspond completely to the requirements placed on them.

The automatic control systems were finally adjusted and ensured operation of the GTU with servicing by a single watch person in the TsPU and the absence of a constant watch in the MO for 16 hours while under way (the GTU was controlled in this case from the wheelhouse) and without a watch in the TsPU and in the engine room during anchorage during berthing and sea trials of the ship "Kapitan Smirnov."
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THE ELECTRIC POWER SYSTEM OF THE SHIP

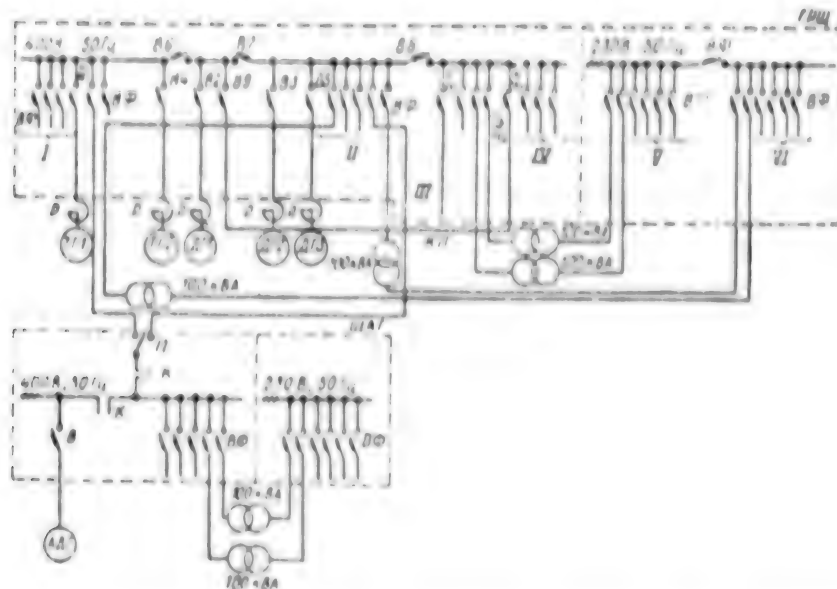
Leningrad SUDOSTROYENIYE in Russian No 3, 1980 pp 37-38

[Article by I. Sh. Muravkin]

[Text] A typical example of modern trends in development of ship electric power systems (an increase of output of the electric power plants, improvement of the electrical equipment and increase of the level of automation) is the ro/ro ship "Kapitan Smirnov." Its EES [Electric power system] consists of three diesel generators and two turbogenerators operating on steam from a utility boiler. The DG1-DG3 diesel generators are made up of synchronous generators of type MSK 1250-750 with rating of 1,000 kW each (400 V, 50 Hz, 750 rpm and nominal power coefficient of 0.8). The generators permit operation with elevation of ambient temperature to +50°C and outside water to +28°C with reduced power by 5 and 10 percent with closed and open ventilation cycle, respectively.

Current-limiting reactors (overall dimensions of 1,700 X 1,020 X 800 mm) with inductive impedance of $x_{rn} = 14.4$ mohms are installed to limit the pulsating short-circuiting current; the value of nominal current is 1,800 A, the calculated resistance is assumed equal to 90 percent of that established with regard to the tolerance for manufacture of $x_r = 13$ mohms and the effective resistance is assumed equal to 10 percent of the inductive impedance in the heated state. The voltage automatically maintained above the nominal by the value of the pressure drop in the reactor can reach 420 V and operation of the generators is permitted only if the nominal current is reduced to 1,720 A at $\cos \varphi = 0.8$. Thus, the power which the system can receive from each generator is 950 kW. Capacitors are used to increase the power coefficient of the EES. An emergency diesel generator supplied with a generator of type MSB 102-4 with rating of 200 kW is provided; the initial excitation achieved without an outside power supply source is accomplished reliably at rotational speed of 0.9 of nominal.

The GRSch and the apparatus installed on it provides the following main roles together with the automated EES remote control panel and the "Izhora-6" automatic system: prolonged single operation of any generator to the branch buses and separate operation of each generator to its own bus



Single-Line Schematic Diagram of Electric Power Plant Consisting of Five Generators With Sequential Switching Reactor: I and II--main and reserve users of running mode; III--"Power supply from shore" feeder; IV--anchorage mode users; V--main lighting and radio communications; VI--outside lighting; galley and heaters; V--automatic selective switch; VF--automatic feeder switch; K--contacts; P--switch; R--current-limiting reactor; KP--cable connector; ShchAG--emergency generator panel

sections, prolonged parallel operation of TG1 and TG2 and DG1 and DG2 in pairs, respectively, to their own bus sections, prolonged parallel operation of any three and four generators to the GRShch busses, temporary (during load conversion) parallel operation of five generators and brief (during load conversion) parallel operation of any generator with the "Shore power supply" feeder.

Such operations as signal generation for automatic starting and switching on the reserve diesel generator when load of 0.9 of nominal on the operating generator is reached, automatic distribution of the active load between parallel-operating generators, automatic precise synchronization of generators with the GRShch busses and semi-automatic synchronization of generators with the on-shore power system, remote (manual) precise synchronization of generators with the GRShch busses and with the on-shore system, remote control of the automatic generator devices, automatic unloading of the generators by switching off the secondary users with time delay (in two stages), light and audio signalling during response of each stage, protection of users upon breaking of the "shore power supply" feeder phase and signalling about a decrease of voltage on the GRShch busses, monitoring the insulation resistance of power systems with voltage of 380 and 220 V, remote control of the servo motors of diesel generators and turbogenerators, light and

sound signalling about a decrease of load of parallel-operating generators below 25 percent of the nominal, monitoring the output, current, voltage, frequency, power coefficient, excitation current of the generators, the current and voltage of the "Shore power supply" feeder and also the current in the feeders of crucial users.

The ship electric power system provides maximum current protection of the generators against short-circuiting currents (t.k.z.) with disconnection of the corresponding selective switches on the GRShch, protection of the feeders going from the distributing sections of the GRShch and from the t.k.z. by means of adjusting switches, protection of the main generators against conversion to the motor mode by reverse power relays acting on the generator switches, protection of the generators against overload accomplished by the UTZ-1A current protection device, minimum protection of the generators and the "Shore power supply" feeder with time delay of two seconds by means of minimum disconnectors of the corresponding switches, protection of users upon interruption of the "Shore power supply" feeder phase by means of the ZOFN-1 device and protection against t.k.z. in the control circuits of the GRShch by means of fuses and automatic circuit breakers.

Emergency, warning and actuating signalling, which permits visual monitoring of the state of the entire electric power system, is provided. All signals are grouped by the feature of related events on the automated EEU remote control console: those carrying information about the condition of the turbogenerator or diesel generator--on the corresponding sections of the turbo- and diesel generators--and signals about the condition of the entire EES--on DG1, DG2 and DG3 sections.

Thus, the electric power plant with rating of 5 MW on the ship "Kapitan Smirnov" has effective protection against short-circuiting current provided by using current-limiting reactors; the automatic system of "Izhora-6" type permits conversion to non-watch maintenance of the electric power plant; the use of the exhaust gases of the main power plant turbines for the two turbogenerators, which generate electric power during the running mode, considerably exceeds the operating economy of the ship.

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AUTOMATIC INTEGRATED SHIP/NAVIGATION/CARGO-HANDLING CONTROL SYSTEM

Leningrad SUDOSTROYENIYE In Russian No 3, 1980 pp 39-41

[Article by A. A. Koshevoy, M. B. Dorisov and A. I. Podlesnyy]

[Text] Construction of large specialized ships, the increase of their displacement, speeds and the intensity of shipping and the need to reduce the anchorage time and to achieve the maximum economic effectiveness of their operation required development of automate ship-handling, navigation, planning and monitoring of cargo processes based on computer technology. The use of these complexes permits a significant increase of navigation safety, competitiveness and economic effectiveness of their operation. Several types of automated ship systems have now been developed in a number of countries.

A complex automation system of "Bris-1" type, which solves ship-handling, navigation and cargo operation problems [1-3], which has received high marks of piloting personnel and operating services, was developed in the Soviet Union and underwent extensive trials on tankers of the "Kryn" class in 1975-1976.

The appearance of large-capacity ro/ro ships, which transport a large variety of various cargo, led to the fact that compilation of the cargo plan of each ship becomes an ever more laborious process which requires high qualifications of the executors and prolonged time. Thus, compilation of the cargo plan for ro/ro ships of the "Magnitogorsk" class with calculation of the seaworthiness-strength characteristics is carried out by two experienced specialists and occupies approximately 40-50 hours. Therefore, automation of the given processes on ships is a timely problem.

The "Bris-1609" system was developed on the basis of the "Bris-1" system with supplementation of the apparatus complex for automation of cargo operations. A complex block diagram of the system is shown in Figure 1. The system includes:

--the radar complex of a two-band NRLS [Navigation radar] (3 and 10 on);

--the "Bris-N" automated navigation system,* which includes ship location equipment, short-, medium- and long-range radio navigation systems, automatic ship course plotter and other devices;

--an information-computer complex which includes a specialized ship-board digital computer (STsVM), collision-warning, monitoring and recording devices;

--a hydroacoustic log complex;

--cargo operations planning and monitoring complex.

Navigation and ship-handling information is automatically entered in the system from the on-board navigation equipment and can be corrected manually and information is entered in part of the cargo operations only manually in the "man-machine" dialogue mode.

The "Bris-1609" system provides:

--solution of navigation problems jointly with the "Bris-N" system;

--display of the surface situation with automatic detection of ships;

--collision warning (automatic tracking of 12 objects, processing the parameters of motion of the object, signalling the danger of collision and automatic avoidance maneuvering);

--making operational calculations;

--recording of external and intraship information (automated management of the ship's log);

--compilation and checking of the cargo plan;

--monitoring loading and unloading of the ship.

All problems are solved by using the "Bris-1609" system when performing cargo operations. The operator arranges the groups of cargo on the basis of information about the voyage. Data on the composition of the groups and loading of each deck are shown on the display. The sequence of loading and unloading and the fuel and ballast distribution are monitored automatically. The system calculates and displays the fit, strength and stability characteristics of the ship in all operating modes. The degree of utilization by area and volume and also calculation of the load capacity as a whole are considered during cargo operations. Data on the ship's characteristics and the cargo plan and on filling the tanks are printed out automatically. The

* See the article of A. Yu. Zharnovskiy, Ya. G. Ostromukhov and B. S. Rivkin "The 'Bris-N' Automated Navigation System," published below (the editors).

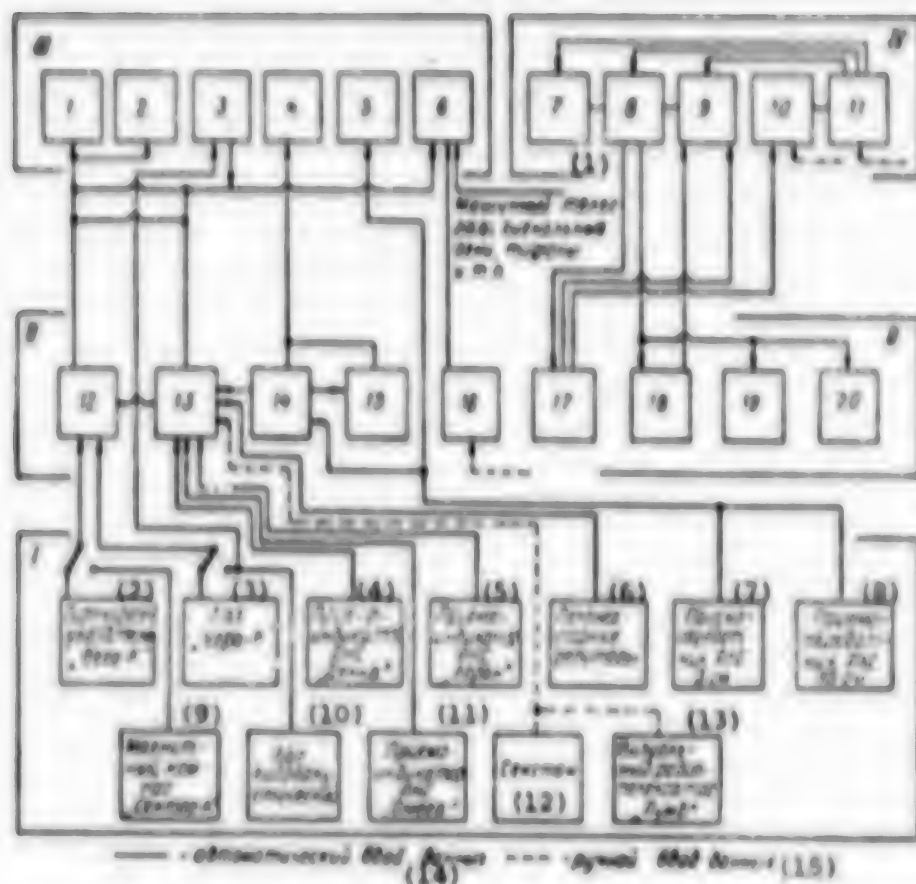


Figure 1. Block Diagram of "Bris-1609" System: I--navigation information sensors; II--STaVH; III--data display equipment; IV--cargo operations equipment; 1--digital navigation data display; 2--automatic plotter; 3--hydroacoustic log display; 4--situations display; 5--navigation situation display; 6--data (teletype) recorder; 7--cargo arrangement display; 8--cargo operations equipment display; 9--data recorder of cargo operations equipment (teletype); 10--tallyman console displays; 11--cargo operations console; 12--dead reckoning; 13--dead reckoning correction; 14--automatic tracking of observed objects; 15--analysis of situation and selection of maneuver; 16--periodic calculations and economic-operational problems; 17--calculation of seaworthiness-strength characteristics of ship; 18--calculation of centers of gravity and volumes of cargo groups on deck; 19--calculation of extent of utilization by area and volume; 20--calculation of total mass of arranged groups of cargo.

Key:

1. Engine telegraph, signal lights, signal whistles and so on
2. "Vege-K" gyro course indicator
3. "Ugra-K" log

(Key continued on following page)

Key (Continued from preceding page):

4. "Decca" radio navigation system receiver-display
5. "Loran" radio navigation system receiver-display
6. Bearing repeaters
7. 3-cm radar transceiver
8. 10-cm radar transceiver
9. "Sektor-K" magnetic compass
10. Hydroacoustic log
11. "Omega" radar receiver-display
12. Sextant
13. "Rumb" visual radio direction finder

tapes are also punched continuously and the data from them are entered in the STsVM, information is recorded on a tape recorder and read from it and so on.

The planning and cargo operations monitoring equipment complex of the "Bris-1609" system consists of a cargo operations console, recording devices, tallyman consoles, nonvolatile storage block and integration and coupling devices with the STsVM.



Figure 2. Cargo Operations Console and Recording Device

The cargo operations console permits operational solution of the problem of compiling the preliminary plan of cargo operations and checking the cargo plan presented by the port. Moreover, performing cargo operations on the

ship is also monitored from the console and graphical information about the disposition of groups of cargo on all decks also comes in, which provides the operator with the data required to compile the cargo plan and to monitor and control cargo operations (including the seaworthiness-strength characteristics of the ship). In this case the preliminary cargo plan can be compiled within 3-4 hours. The recording device (teletype) permits documentation of all the entered and printed information, the preliminary cargo plan with calculation of the seaworthiness-strength characteristics of the ship and also provides solution of additional problems entered in the STsVM from the punch tape. The cargo operations console and the recording device are located in the cargo operations control station (PUGO). An external view of these devices is shown in Figure 2.

The tallyman consoles can be connected to 19 special boxes located on all decks (from 3 to 6 boxes on each deck), which provides entry of information about the cargo characteristics (the numbers of the builds of lading, the number of berths and on on), its specific arrangement (according to the frames or the length of the ship) and also signalling on different disturbances on conducting cargo operations on the ship. The possibility of connecting two tallyman consoles in each block is provided (Figure 3).

A standard magnetic tape store is used as the external storage. The device is designed to record and store the cargo plan, various programs, ship constants and other information required to compile the cargo plan. It is connected to the STsVM and the cargo operations console by a special integration block.

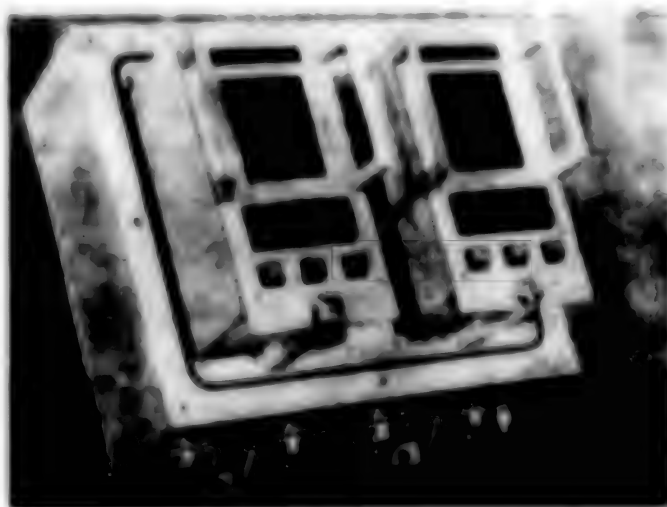


Figure 3. Box With Two Tallyman Consoles

The software of the "Bris-1609" system permits compilation of the cargo plan of the ship "Kapitan Smirnov" in the cargo operations mode with regard to visits to five ports and calculation of the fit, strength and stability characteristics at all stages of compiling the cargo plan and monitoring the cargo operations on the ship. Disruption of any of the mentioned calculating characteristics of the ship is accompanied in this case by lighting up of the transparencies on the tallyman consoles, the cargo operations console and sound signalling.

Working with the apparatus for automation of cargo operations does not require high qualifications of the operator. For convenience of operation of the port services and to accelerate ship handling deadlines, the previously compiled cargo plan is duplicated on punch tape, by which it can be duplicated in the required number of copies. The use of apparatus for automation of cargo operations renders effective assistance to the port services having no computer centers and will also contribute to clearer organization in interaction of port and ship services during operation of ships of the "Kapitan Smirnov" class.

The level of automation provided by the "Bris-1609" system permits:

- an increase of the navigation safety of the ship and its operational speed;

- improvement of the utilization factor of the ship's cargo spaces (by area and volume);

- a significant reduction of the time required to compile the ship's cargo plan;

- automation of tallyman accounting of loaded and unloaded cargo;

- monitoring the calculated seaworthiness and strength characteristics of the ship;

- reduction of the anchorage time of the ship;

- more complete accounting of all external and intraship information, reduction of it to generalized form easily perceived by ship captains;

- documentation of all input and output information.

The results of experimental operation of the cargo handling apparatus on the ship "Kapitan Smirnov" and software processing permit consideration of the problem of using the "Bris-1609" system on other large-capacity ro/ro ships as well.

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THE 'BRIS-N' AUTOMATED NAVIGATION SYSTEM

Leningrad SUDOSTROYENIYE in Russian No 3, 1980 pp 41-43

[Article by: A. Yu. Zharnovskiy, Ya. G. Ostromukhov and B. S. Rivkin]

[Text] The navigation problems on the ship "Kapitan Smirnov" are solved by means of the first domestic "Bris-N" automated navigation system (NK) contained in the "Bris-160V" automated ship-handling, navigation and cargo operations system.*

The "Bris-N" system includes:

- a) the small "Vega-K" reserve gyro course indicator (GKU) in the gyro compass and gyro azimuth modes;
- b) the "Sektor-K" magnetic compass (MK) with remote transmission of the heading;
- c) the "Ugra-K" induction electronic log which measures the ship's longitudinal speed with respect to the water;
- d) a receiver-indicator which operates from the signals of the "Decca" radio navigation system (RNS) and which constantly determines the data from three (two) position lines;
- e) a receiver-indicator which continuously puts out readings from the three position lines of the "Omega" RNS;
- f) a receiver-indicator which permits sequential determination of the readings by one of the position lines of the "Loran-A" or "Loran-C" RNS;
- g) the "Rumb" visual radio direction finder;

* See the article of A. A. Koshevoy, M. B. Borisov and A. I. Podlesniy, "Automatic Ship-Handling, Navigation and Cargo Operations Control System," published above (the editors).

h) the automatic ship dead reckoning plotter on mercator projection maps;

i) power supply, relay and signalling devices, including heading and speed repeaters.

Moreover, data from the hydroacoustic log (GAL), which measures the longitudinal and transverse speed components of the ship's bow and stern with respect to the bottom at depths up to 150 meters, are used in the system.

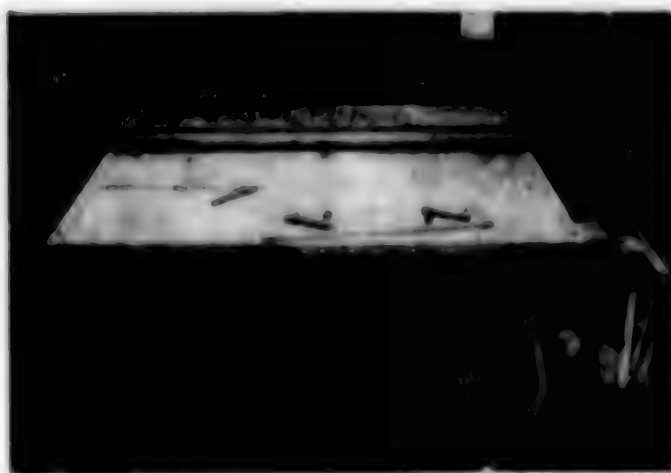


Figure 1. Automatic Dead-Reckoning Plotter

All the navigation information sensors (except the "Rumb" direction finder) are integrated with the information-computer complex (IVK) contained in the "Briz-1609" system, by means of which navigation problems are solved and the dead reckoning plotter is automatically controlled. It should be noted that the distinguishing feature of the "Briz-N" NK is the presence of two central gyroscopic devices in the GKU, one of which is used as a backup. This made it possible to reduce to essentially zero the probability of failure when solving the problem of determining the ship's heading. The automatic plotter (Figure 1) is an essentially new device, having a ball-helical gear instead of the ordinary worm gear. It is controlled by the STsVM contained in the IVK. The dimensions of the working field of the plotter are 680 X 930 mm. Control from the STsVM provided dead reckoning of the ship on maps of any scale (from 1:10,000 to 1:1,000,000), while use of the ball-helical gear reduced the instrument error of the plotter to 0.3 mm and permitted a sharp reduction of the travel time of the recording assembly. The total display error on the map of the ship location coordinates stored in the STsVM does not exceed 0.8 mm.

The developers held to the following principles during development of the automated "Briz-N" NK:

- provide the possibility of autonomous use of all the apparatus contained in the complex;

- utilize the operations traditionally carried out in the presence of ordinary navigation devices when organizing the process of the ship pilots interaction with the NK and IVK apparatus;

- use modern statistical methods of navigation data processing in the NK software;

- all display panels and control blocks for operation of the systems contained in the NK should be configured on a common console.

Practically all the main apparatus in the navigation console (Figure 2), carried out in the form of standardized sections of two dimensions which can be used on ships of different classes and tonnage, could be concentrated as a result of the investigations.



Figure 2. Navigation Console

The navigation console is located in the navigation room.

Problems solved by the "Briz-N" NK. The considered navigation complex is used to measure the ship's speed and course and to relay information to

users, to determine the ship's location and to indicate it on the chart and also to pilot the ship along a given trajectory. The following problems are solved in this case by using the IVK:

- a) self-contained calculation with estimate of accuracy;
- b) plotting with information display on the plotter;
- c) determination of the ship's location by using the "Decca," "Omega," "Loran-A" and "Loran-C" radars, by measuring the altitudes of "navigation" stars and also from data on the bearing and range to a fixed reference point with known coordinates (worked out in the radar complex contained in the "Briz-1609" system);
- d) calculation of the position line elements with variations of solar elevation;
- e) working out the route coordinates;
- f) making special calculations (data for navigation along the great circle, compass correction, wind drift angle, time of sunrise and sunset, navigation distance and time to a point with known coordinates, forecasting of ship's coordinates by known values of course and navigation speed and time);
- g) determination of ship and Greenwich time.

The ship's location is determined by the RNS, RLK and stars as solution of the problem of complex data processing of the calculation system and the corresponding measuring equipment. The algorithm for the reduced suboptimum Kalman filter [1], which permits one to find corrections to the calculated coordinates of ship location and to the speed measured with respect to the log from data of the "Decca" RNS and RLK (these problems are solved at a rate of 3 minutes and 1 minute, respectively), and in some cases corrections only to coordinates (when the correction is made periodically), is used in this case. There is the "measurement oversight" rejection block in the algorithm to increase the reliability of the results obtained and the effects related to linearization of the processed signals are also taken into account. Finally, the IVK provides solution of the indicated correction problems also by the traditional method of intersection of the position lines.

Interaction of the equipment of the complex. When the ship leaves port, the GKU, the "Ugra-K" relative log, the MK and the course translation mechanism should be switched on (the MK is used in the given complex as standby equipment and serves only for monitoring purposes with a functioning GKU). In this case the course determined by means of one of the GKU channels, the speed and distance covered are displayed on the front panel of the electronic navigation section of the navigation console and are related to users.

The heading is recorded on the course plotter tape, which is located on the stern bulkhead of the navigation room. During operation there is continuous comparison of the course determined by means of the GKU and MK (with regard to the values of magnetic declination and residual deviation). If the established range of deviations of the GKU and MK readings is exceeded, a warning signal is transmitted to one of the instruments of the automatic signalling system also located on the stern bulkhead. In this case the display board "GKU and MK error" lights up on the instrument with a blinking light and an audio signal is transmitted. The audio signal is switched off when a special button is pressed and the display board lights up with an even light until the reason causing the appearance of the warning signal has been corrected in the apparatus. In the given case the pilot should analyze the MK and GKU readings and should either switch off the MK if it is malfunctioning or should connect the heading translator (in which the headings are being compared) to the functioning GKU channel. A warning signal will not be generated in this case and the signal board is extinguished.

It should be emphasized that the most diverse emergency-warning signals which indicate failure of one or another piece of equipment or which provide the pilot with information about the state of the complex (signals of the type "plotter on lock," "enter speed into IVK" and so on) are generated in a similar manner in the instruments of the automatic signalling system.

The ship time sensor is switched on prior to the beginning of solving the calculation problem and the input information is entered in the IVK: the geographical coordinates of the point at which the ship is located at the current moment of time, the value of the mean square error of their determination by the pilot and so on. The teletype contained in the IVK and located in the section of the navigation console (Figure 3), which is the IVK control device, is used for this. Data input requires that the pilot print out the conditional combination of ciphers on the teletype tape corresponding to the calculation problem being solved, after which the IVK is automatically interrogated in a specific sequence determined by the algorithm and the state of the NK apparatus and the required input data, while the pilot enters them by using the teletype. After input of all data is completed, the "Start" key on the IVK control device should be pressed and the calculating problem will be solved automatically. The results of the solution are displayed on the information board of the IVK control console.

The input data for all remaining problems to be solved in it are also entered in the IVK in a similar manner. Moreover, only the data which were previously not entered must be entered from each of them or they will not automatically be entered in it (such as the heading, speed, readings of the RNS receiver-indicators and so on).

If automatic plotting must be carried out, the IVK controls the solution of this problem, for which the data of the geographic chart are entered from

the teletype into the STsVM and the automatic plotter tracking devices are switched on. The recording assembly of the plotter then begins to trace the ship's path continuously on the chart.

If the problem of calculating the ship's course is solved in the IVK, the coordinates of the ship's location can also be corrected from RNS, RLK and astronomical measurement data. To do this, the IVK is switched on to solve the corresponding problem, the star elevations measured by means of a sextant are entered manually into the IVK by means of the teletype and the data from the RNS and RLK receiver-indicators are entered automatically (moreover, the necessary information on the parameters of the different RNS circuits is stored in the permanent memory of the STsVM).

If the periodic problem is being solved in this case (determination of location by the "Omega," "Loran," RNS and by the stars), the resulting coordinates of the observed location are displayed on a chart set on the plotter. The recording assembly then again returns to the point to be calculated. Only after the pilot has made the decision are the non-ties added to the coordinates to be calculated. If the continuous problem is solved (determination of location by the "Decca" RNS and RLK) the observed coordinates of the ship's location and those to be calculated are first alternately displayed on the chart. After the pilot takes into account the results of correction, the NK is converted as matters dictate to the observation navigation mode when the ship's location, found as a result of solving the complex RNS data processing problem and the calculating system, is displayed continuously on the chart.

We note that automation of solving problems of correcting the ship's location to be calculated permitted a sharp reduction of the time of finding the observed coordinates. Thus, an experienced pilot wastes no more than five minutes on solving the problem of determining location by the elevations of 6-7 stars, including the time of measuring their elevations with a sextant, which is several times less than the time required to solve this problem by traditional methods using tables.

It is significant that the coordinates of fixed reference points used in determining location by the RLK can be entered in the IVK both manually and automatically with special operating mode of the plotter [2], which provides entry of the coordinates of any point of the map placed on it in the operative memory of the STsVM. To do this, it is sufficient only to combine the recording assembly of the plotter with this point and to press the special key. The indicated mode (also used for automatic entry of the coordinates of the absent point in the calculation problem or the point of rotation when working out the route coordinates) permits a sharp reduction of the number of manual operations to enter data and practically eliminates the subjective errors of the pilot.

When determining the ship's location by the sun at mean latitudes, measurements of its elevation at intervals of 1.5-2 hours are required. Only the



Figure 3. Section of Navigation Console--IVK Control Device

elements of the position line of each measurement--the value and direction of transfer--are determined. The observed location is determined manually by the pilot in this case by using the graphic plots, after which the derived discrepancies are entered through the teletype in the coordinates to be calculated and stored in the IVK memory.

The problem of correcting the location to be calculated from data of optical direction finding is also solved in the NK during the final step by graphical plots. In this case the pilot, taking a bearing of any sure reference point, presses the button located on the bearing repeater. The value of the bearing is automatically printed on the teletype tape and the electromagnet, which elevates the writing assembly by 45-60 seconds, is triggered in the plotter and as a result the interruption which records the ship's coordinates to be calculated at the moment the bearing is taken occurs in the course line.

Finally, solution of the problem of working out the route coordinates, which is informational in nature, should be especially mentioned. The coordinates of the point of rotation, the width of the corridor on each segment from which the ship should not emerge during motion and the radius of the circle maintained around the point of rotation, upon intersection of which the pilot should be given a signal of the need to change course, are entered as the input data in this problem according to the preliminary plot

made by the pilot. The distance to the nearest turning point and the value of the transverse motion with respect to the line of a given course, which are also displayed on the information panel of the IVK control device, are calculated continuously from the moment the problem on the calculated or observed (with correction) coordinates of the ship's location begins to be solved. If the ship goes beyond the given corridor or intersects the guard ring (on the situation display), a signal is issued by the automatic signalling system which attracts the pilot's attention. In the first case a course maneuver directed toward reducing the transverse motion must be made and in the second case a new heading must be taken whose value is printed on the teletype tape. The new heading ensures the ship's motion to the next point of the turn with regard to its maneuvering characteristics. Tests showed that the error of calculating the transverse motion of the ship with respect to a given heading does not exceed 20-30 meters if there is continuous correction of the calculated coordinates of location from RLR or "Decca" RNS data (in a zone with "good configuration").

Conclusions. Tests of the "Bria-N" NK carried out on the ship "Professor Ukhov" and the experience of operating it on tankers of the "Krym" class confirm the correctness of the technical solutions adopted in design of it. These tests also showed that it is not inferior to the best foreign models of the same years of development in the volume of problems solved in the NK and the level of their realization. Nevertheless, further improvement of the complex is now required such as:

- the complex is not self-contained since it relies on the same IVK in which, moreover, problems of collision warning, recording, cargo operations and so on are solved;

- there is no receiver-indicator of a satellite navigation system in it;

- the values of latitude and speed are entered manually in the reserve channel of the GKU;

- there is no possibility for operational entry of corrections to the readings of the relative log and the GKU.

These comments are being taken into account in development of the second-generation NK now being carried out for larger- and medium-capacity transport ships.

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FEATURES OF TECHNOLOGY AND ORGANIZATION OF CONSTRUCTION OF THE SHIP
'KAPITAN SMIRNOV'

Leningrad SUDOSTROYENIYE in Russian No 3, 1980 pp 44-46

[Article by Yu. I. Makarov, L. K. Nazarov and I. I. Mel'nichenko]

[Text] The design features of the ro/ro ship "Kapitan Smirnov" made it necessary to develop new principle production processes, design and manufacture of complex special production equipment. The main propositions on the technology and organization of constructing these ships, which envisioned analytical coordination of the hull lines, machining of sheet metal on machines with program control, the possibility of using large-size sheets, the large-volume of flat sections and their manufacture on a mechanized line, reinforcement of sections on pre-way assembly sites, combination of copper pipe and mechanical-installation operations with hull-shaping operations, combination of machinery and enclosing pipelines in panels, were developed even during coordination of the detail and control designs. During issue of the detail plans, the specialists of the design and technological services of the plant entered the necessary data and production instructions in the drawings to provide the possibility of computer processing of documentation and to reduce the deadlines of starting its production at the plant. Data for supplying the shops with MSCh [Modified gray iron] products, deliveries and materials and also data on ordering MSCh products and materials were issued as a result of computer processing of the documentation. All printouts of these data were obtained by using a computer. The programs for the gas-cutting machines of type "Kristall," approximately 30 principal production processes including those for outlining the sections "in net dimensions" using optical instruments, manufacture of flat sections on a mechanized line, installation of the main gas-turbine units and steering gear and also installation of the inclined stern ramp, deck and bulkhead covers, automobile platforms and so on, were developed during production preparation for construction of the pilot ship "Kapitan Smirnov."

Figure 1. Configuration of Section "In Net Dimensions" in Assembly-Welding Shop.

The rolled sheet metal was machined on mechanized lines of the hull-shaping shop. All the sheet and sectional material was first straightened,

cleaned and primed before the start of machining. The sheet parts from 7 to 10 mm thick were cut according to the programs on the "Kristall" gas-cutting machines. The hull was partially assembled from a symmetrical strip-bulb section which permitted a reduction in the volume of production of welded T-beams.

Flat sections were manufactured on a mechanized line and the remaining sections were assembled on beds. Approximately 60 percent of the bottom, side and deck sections were subjected to shaping "in net dimensions" by means of optical instruments, which permitted a significant reduction of the volumes of fitting operations on the ways (Figure 1). The ship hull was constructed on an inclined way and it was reconstructed simultaneously with shaping of the hull. The MHD (Engine and boiler room) compartment was initially laid in the upper part of the way where the necessary operations were carried out. After the lower part of the way was reconstructed, the compartment was lowered to its permanent position. Modernization of the underwater part of the way was completed by the moment the ship was launched, for provision of which a launching device which provides the use of special metal slips and buoyancy tanks, was designed and manufactured.

The ship hull was shaped from sections and blocks reinforced on the pre-way sites--their mass reached 240 tons; the superstructure was assembled from three blocks from 180 to 260 tons of mass (Figure 2). The sections were transported from the assembly-welding shop to the pre-way sites on railroad flat cars and the bulkheads, screens and also the outer walls of the superstructures were transported in containers. The anchor gear of the ship includes all-welded chains of increased strength, manufactured on a specialized section (Figure 3).

The panelled ceilings in the hulls and tweendecks were designed and introduced during construction of the ship "Kapitan Smirnov." Panels having dimensions of 600 X 1,250 mm were manufactured from boards 32 mm thick and were edged by strips of thin-sheet steel. The panels were attached to the ceiling by means of removable suspensions. This made it possible to avoid the use of welded suspensions and reduced the consumption of lumber. The rudder and deadwood gear was installed on the ways by using special production equipment which includes metal supporting columns moved along rails on a dolly (Figures 4 and 5). The need to develop this equipment was caused by the design features of the stern end of the ship and by the large mass dimensions of the devices. Platforms with hangers to locate the parts of devices, equipment and attachments, which facilitate installation operations, were provided on the columns. The rudder blades, deadwood pipes, screw shafts and screws were installed by using pipe and hydraulic turn-buckles and jacks.

Operations to load and install the units, panels, machinery and equipment and also manufacture and installation of the pipelines of the general ship systems (Figures 6 and 7) were carried out in parallel with shaping of the hull. The conditions for delivery of the main gas-turbine units and the





Figure 2. Installation of Reinforced Section of Upper Deck



Figure 3. Section for Manufacture of All-Welded Anchor Chains From Rolled Steel



Figure 4. Installation of Screw By Using Special Equipment Located on a Movable Dolly

scheme for packing the RO25 reduction gears provide for monthly pumping with working oil after they are loaded on the ship and maintenance of plus temperatures in the MO room. Therefore, the main gas-turbine units (GGTA) were installed only a little before the beginning of dockside trials of the ship. To do this, production cuts measuring 6 X 8 meters were made in four decks. Earlier periods of GGTA installation installation can be accomplished only if the scheme for preserving the reduction gears is changed.

The detail plans provide for manufacture of 27 units and zonal installation blocks and also of 56 panels. The panels and units were placed on permanent foundations during hull shaping and were installed before installation of the overhead decks. The timeliness of delivering the complete products for the units is of important significance with this method of installation. Effective introduction of unitizing is possible only with strict observation of their delivery deadlines.

The design feature of the gas-turbine ship "Kapitan Smirnov" is the absence of cargo hatches in the decks, through which machinery, equipment and materials could be delivered by cranes to the holds and tweendecks. The

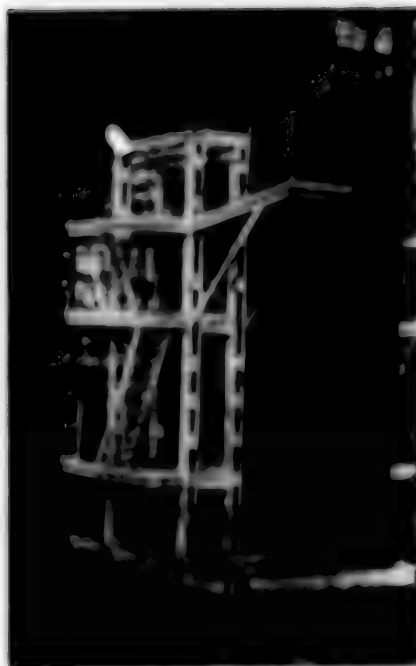


Figure 3. Installation of Rudder Blade

stern ramp had to be installed and functioning of it had to be provided and the openings in the decks and bulkheads had to be covered long before completion of installation of the permanent hydraulic system to deliver the equipment, materials and products by means of wheeled transport equipment to the ship compartments during construction of it. The operations of raising and lowering the stern ramp and the covers were carried out by special production benches developed at the plant. (Figure 8), which were connected directly to the actuating hydraulic mechanisms (the hydraulic motors of the winches and cylinders). Introduction of these measures made it possible to significantly reduce the delivery of materials, equipment and products to the ship spaces, to reduce the loading of crane equipment and to reduce the laboriousness of loading operations.

Different hydraulic systems are used on the ship "Kapitan Smirnov." A hydraulic section where the pipes are manufactured, cleaned and flushed, was created on the ship in the installation-finishing shop to increase the smoothness of the pipelines of these systems and to reduce the periods for flushing the systems. Preparations for installations of all the hydraulic

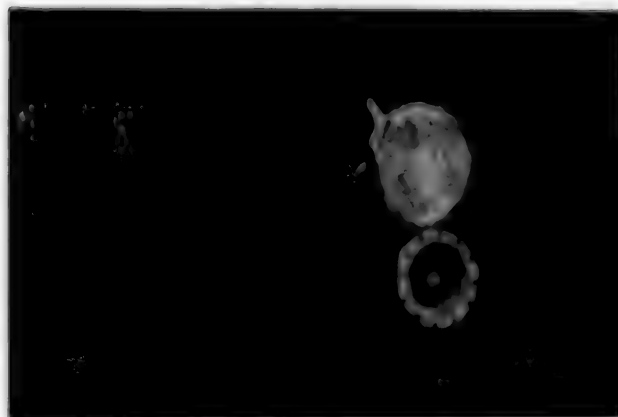


Figure 6. Panels of Pipelines Installed in Passage of Systems

equipment are made here. The presence of a specialized section permitted an increase of the quality and a significant reduction of the periods of flushing the hydraulic systems.

The pipes of the general ship and housekeeping-service systems are manufactured from drawings in the pipe shop. Drawings of the pipes are made from mockups and drawings manufactured during the design stage.

Insulation packets previously manufactured in the shop and also batt insulation were used in insulating the ship spaces. Containers for delivery of pipelines, materials and equipment to the ship, which were transported by lift trucks and other equipment, were used extensively during construction of the ship. Portable storehouses and shops which were installed on the upper deck were used to reduce the losses of working time on the ways and when the ship was afloat. Operational management was accomplished by means of telephone communications with the ship NKO and TsPU and by radio relay equipment.

Panels of "chernomerit" construction material and flame-resistant laminated plastics reinforced along the edge by a plywood strip 10 mm thick were used to finish the ship spaces. The latticework parts and finishing panels were manufactured in the shop and were delivered to the ship in containers and in sets according to spaces. As a result, operations to finish the cabins were reduced to installation of these elements without additional finishing. This permitted a reduction of the laboriousness of finishing operations on the pilot ship and organization of manufacture of the wall elements regardless of the status of hull-shaping operations.



Figure 7. Water-Distillation Installation Installed on Foundation During Shaping of the Ship's Hull

A number of prototype models of equipment was installed on the ro/ro ship "Kapitan Smirnov." Among them are the DI59 gas turbines, PTU2 steam turbines, RO25 reduction gears, PU500 steering gear, turbogenerators and diesel generators, KUP 3100 utility boilers, six types of waterproof covers in the bulkheads and two types of horizontal covers of the spans in the decks, noncoaming hatch cover, hydraulic automobile platforms, ShEl3-1 capstan and also the "Briz-1609," "Shipka U-7," "Naroch'-6," "Raskat," and "Izhora-6" automatic systems. Installation and adjustment of the complex imported equipment--the stern ramp of the MacGregor Company, the washing installation of the fuel-preparation system of the Sharpless Company, the gas analysis systems of the Salvico Company and others--were provided at the same time.

These are the main features of technology and organization of construction of the pilot gas-turbine ship "Kapitan Smirnov."



Figure 8. Special Production Bench Which Permits the Use of the Hydraulic Mechanisms of the Stern Ramp Prior to Installation of the Permanent Hydraulic Systems

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A COMPUTER-AIDED LOFTING AND PRE-PRODUCTION SYSTEM

Leningrad SUDOSTROYENIYE in Russian No 3, 1980 pp 47-48

(Article by V. I. Kozhukhar', A. D. Elison, N. G. Voytenkov and V. A. Lishatov)

[Text] One of the main directions of increasing the efficiency of hull production and increasing labor productivity and product quality is complex mechanization and automation of production processes based on introduction of mechanized lines, machine tools and machines with program control and other modern equipment.

The desire to reduce the laboriousness of lofting operations, to increase their accuracy and to obtain digital information for operation of production equipment with ChPU [Numerical program control] led to the need to replace graphic operations carried out on the loft by the traditional manual method and by analytical calculation. The experience of joint operations with TsNIITS [Central Scientific Research Institute of Transportation Construction] and the use of the institute's developments made it possible to begin automation of individual problems related to turning out lofting-production documentation for construction of the ship "Kapitan Smirnov."

The following operations were carried out by using analytical methods and the computer in construction of the ship "Kapitan Smirnov": analytical coordination of the ship's hull lines, analytical determination of the grooves and structural lines, analytical development of sheets of the outer planking with output of data for computer calculation of the working programs, formation of the expanded mathematical model of the ship's hull, analysis of the detail plans and compilation and computer debugging of procedural descriptions of the structural members of the ship's hull, compilation of the detail plans and procedural descriptions of the input data on the basis of the mathematical model for computer calculation of the shape and dimensions of parts, computer calculation of the dimensions of parts and drawing their profiles on an automated drawing device (Figure 1), computer calculation of the working programs for cutting out parts on machines with ChPU (Figures 2) and computer calculation of data for manufacture of assemblies and sections.

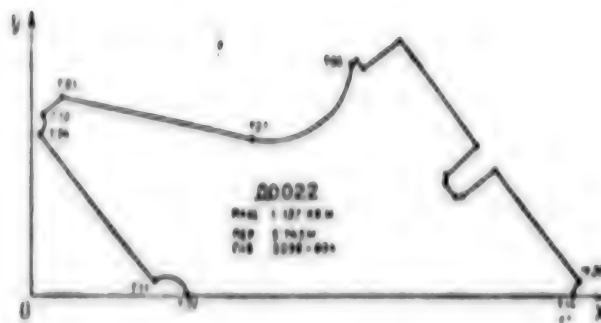


Figure 1. Drawing of Part Produced by Automated Method and Applied to MTK

These operations were carried out during development of the side and bottom sections of the three construction regions. The dimensions of more than 12,000 parts were determined by a similar method by computer calculation and data were issued for assembly of 44 bottom and side sections without manual development on the loft. More than 6,500 control programs for "Kristall" type machines were manufactured.

The use of analytical methods when determining the shapes and dimensions of parts and of machines with ChPU for thermal cutout of parts considerably improved the working conditions of the workers in the hull-forming shop. The expenditures for finishing operations in assembly of the sections were reduced by 15-20 percent by increasing the accuracy of manufacturing the parts. Introduction of analytical detail and programming the cutout of parts showed that making the layout charts of sheet metal with maximum use of parts symmetry has a great effect on reducing the laboriousness of operations during preparation of lofting-production documentation. Some improvement of the "Kristall" machines was made at the plant, which made it possible to cut out parts by a single control program in direct and mirror image, which reduced the total number of control programs.

As is known, permeable or impermeable seals are installed in the notches for passage of a rolled or welded section to provide strength and impermeability of the hull structures. These seals were previously manufactured separately as independent parts. Simultaneous cutout of the main part and seal has been developed and introduced for the pilot ship "Kapitan Smirnov." Procedures which permit computer calculation and receipt of control programs by which the main parts and seals for them are cut during one pass of the cutter and are held together by a crosspiece whose length depends on the mass of the seal were compiled in GEPOS language of the KODS system for typical cutouts.

The annual saving from introduction of analytical methods and cutout of parts on machines of "Kristall" type comprised more than 100,000 rubles during construction of the ship "Kapitan Smirnov."

The main measures directed toward increasing labor productivity and work quality in hull production at the shipyard during the next few years will be expansion of introduction of production documentation calculated on a computer (profile drawings, tables for construction of beds and layout of the points of installing the assembly and so on), further development of analytical methods of determining the shapes and dimensions of parts by using computers, introduction of analytical layout and compilation of sheet-metal layout charts, mechanized drawing of scale divisions on equipment with ChPU, programming of part machining operations (including thermal output with finishing of edges, bending sheets and sections and so on), total replacement of "Odessa" gas-cutting machines which operate from master drawings by machines with ChPU of "Kristall" type and assembly of sections and blocks from parts manufactured without allowances.

Lofting-technological preparation of production also includes putting out planning-accounting documentation. The ever-increasing volumes of work and the increased amount of reference-administrative documentation is becoming a serious hindrance to increasing production efficiency, including hull-processing production. The complexity and possibility of errors appearing in manual selection of requisites make work on automated output of documentation very timely.

Creation of a main norm-reference file on machine carriers is also possible due to the frequent access to this type of information, the possibility of building this file by the modular principle, the reliability and authenticity of the input data, the applicability of standard programs for processing them and also the wide nomenclature of the documents produced.

The norm-reference file is information recorded on magnetic tape in content, which is stored in route-flow sheets (MTK). As is known, MTK are intended to bring the necessary production information to the job sites, to keep a record of machined parts and to pay for work performed. MTK are compiled for parts cut from a single sheet or a group of profile parts included in one pass and machined on the same line. The pass includes parts of sections which comprise a single layout set. Moreover, the possibility of achieving the maximum layout coefficient of metal with a minimum number of simultaneously laid-out sections is taken into account when laying out hull structures by start-ups.

The MTK includes a drawing of the part, a computer-aided layout chart in a scale of 1:10 and specifications. The specialization of the MTK is filled out manually with regard to the fact that metal layout at the shipyard is still not completely automated. The requisites contained in the specialization are recorded on magnetic tape and are used both during manufacture of parts and for preparation of all the necessary planning-accounting documentation. The following documents are issued by means of computer.

The MTK file in the start-up is printout of information contained on the machine carrier for visual checking of the correctness of the created file and of all requisites contained in it.

The list of the MTK in the start-up is a list of MTK ordered by the sheet dimensions, containing information about the amount of metal required for each MTK and the metal layout coefficients.

The list of the need for materials is an ordered list of types of rolled metal which are required to manufacture parts of a given start-up. They lay out coefficients for a given size of rolled sheet and also separately for sheet metal and rolled sections in the start-up are also given here.

The address-parts list contains a list of the parts related to a given drawing with the MTK numbers according to which they are laid out. Moreover, there are data on the affiliation of the part to one or another section, on the assembly section to which this part should be sent and the part number as reference material. One can determine by using this document by compilation with the specifications of the drawing whether all the parts of a given start-up have been taken into account in compilation of the layout charts.

The assignment chart for layout of metal is a list of the materials which must be prepared and sent to one or another metal-machining line of the hull-machining shop. The document serves as its own type of coating according to which the metal is transferred from the warehouse to the shop and also contains the input data (the number and cost of the expended materials) for conducting operations according to cost-accounting.

The assignment chart for machining the metal is an ordered list of layout charts and characteristics of the metal required to manufacture parts from these charts. This document is the official one upon completion of work according to a given start-up after the "executor" and "OTK imprint" column is filled in.

The parts list contains parts of a specific drawing and sections which are sent to a specific metal-machining line, are placed in a given type of container and are subject to be sent to a single section of the assembly-welding shop. The type of container depends on the metal-machining line and the type and dimensions of the parts. Flat sheet parts with mass greater than 16 kg are placed in a container of type "A"; flat sheet parts with mass less than 16 kg are placed in a container of type "B"; parts of bent sheets are placed in a container of type "M"; sectional parts more than three meters long are placed in a container of type "V"; and sectional parts up to three meters long are placed in a container of type "G." The use of several types of containers is caused by the fact that parts of each type are made up at a specific location and by using different means of mechanization--lift trucks, sorters, dumpers and so on.

The summary parts list by containers is a list of sections in a given start-up which come in after a specific machining line to a single type of container. The list is used for preliminary determination of the number of containers required and the locations of the parts.

The summary parts list for a section contains a list and the number of containers of each type in which the parts of a given section are made up for sending to a specific section of the assembly-welding shop; the line for manufacture and making up the parts into containers is also indicated. This document is necessary to determine the completeness of the containers with parts of a given section before they are sent to the assembly section and also to determine the necessary amount of corresponding transport equipment.

The parts list of finishing wastes contains the number, types and dimensions of "finishing" metal scraps formed during layout of the sheets of a given start-up. The list contributes not only to strict accounting of wastes, but also helps to utilize them in manufacture of parts of subsequent start-ups.

Development and issue of the documents indicated above completed the first step of creating computer-aided lofting-technological and planning-accounting documentation. Investigations are now being conducted to automate metal layout and to develop a system of automated standardization of labor. Introduction of these measures will permit automation of the output of all lofting-technological and planning-accounting documentation and, moreover, will help to select the optimum version of metal start-up for machining with regard to the maximum load of the production equipment of the hull-machining shop and to provide complete delivery of parts to the assembly-welding shops of the shipyard.
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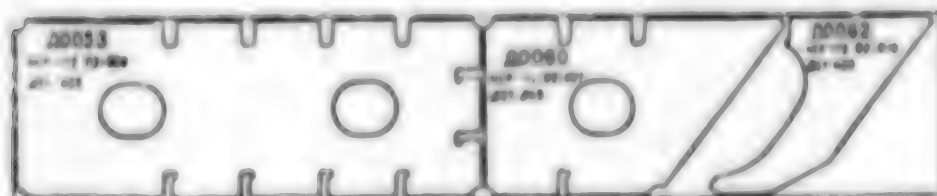


Fig. Control Chart of Layout Drawn by Tracing Device With ChPU

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IMPROVING HYDRAULIC SYSTEM MANUFACTURE AND INSTALLATION

Leningrad SUDOSTROYENIYE in Russian No 3, 1980 pp 48-49

(Article by I. I. Mel'nichenko and G. M. Vyazov)

[Text] The amount of equipment and devices operating from hydraulic drives has recently been increasing on ships. Hydraulic drives are dependable and easily subject to remote and automatic control; they are capable of creating rather large forces with relatively small dimensions. A considerable amount of equipment and devices operate from hydraulic drives on ro-ro ships of the "Kapitan Smirnov" class. These are six vertical impermeable cargo covers operating from dual-action cylinders, 10 automobile platforms, an automobile ramp and two horizontal cargo covers set into operation by means of one-way hydraulic cylinders, the stern door and the inclined ramp whose operation is provided by means of 12 cylinders and two hydraulic winches, the fittings of the general ship systems and the ventilation caps operating from piston-type hydraulic drives and also the rudder, sliding doors and the mooring capstan.

Hydraulic drives also have some disadvantages along with their advantages. One of them is their high sensitivity to contamination of the working fluid. The main integrated parts of hydraulic drives are connected with small clearances; if mechanical impurities get into these clearances, scores appear on the parts, as a result of which the parts may be subject to seizure and the mechanism may fail. There are increased requirements on the cleanliness of hydraulic equipment during assembly at the manufacturing plants and on the pipelines of the hydraulic systems, which are manufactured and installed at ship construction enterprises.

The total length of the pipelines of the hydraulic systems on the container carrier "Kapitan Smirnov" is approximately 36,000 meters. To provide cleanliness and operating reliability of all the hydraulic equipment, it became necessary to change the technology of manufacture and installation of the hydraulic systems.

A specialized section for manufacture, chemical cleaning, washing, testing and installation of hydraulic systems, fittings and hydraulic units now

functions in the installation-finishing shop. It consists of the following departments: pipe preparation, chemical cleaning of pipes, assembly and washing of hydraulic parts and pipes of the hydraulic systems.

All the machines and equipment in the pipe-preparation department are arranged strictly according to the production process. This department has its own x-ray laboratory where the last checking operations are carried out. The sequence of pipe manufacture is as follows: cutting, bending, preparation of the ends for welding the end fittings, preparation and welding of the end and branching fittings, cleaning the welded joints, testing for strength and radiography of the welded joints. The welding stations (Figure 1) consist of three blower-equipped benches with removable gratings. The station for welding in a protective gas medium (including an argon medium) is located separately. The ventilation ducts of the welding benches are protected by metal sheets which form the body on which the welding station apparatus is placed. Fittings can be welded to pipes up to six meters long on each of them.

The pipes are tested on a specially allocated platform equipped with benches which permits a pressure of the tested medium up to 3,600 Pa to be created. The platform is separated from the pipe-preparation section by a metal baffle.

After radiography, the pipes are sent to the chemical cleaning section. Pipes with arbitrary diameter greater than 14 mm are placed in containers and are treated with the corresponding solutions by submerging into baths. A special bench with forced circulation of the solution, on which the solutions are pumped by a special pump through each pipe until complete cleaning of it, has been manufactured for chemical treatment of smaller diameter pipes. After caps are placed on the pipes, they are sent to the department for assembly and washing of the hydraulic equipment and pipes of the hydraulic systems. There are three rooms here: a pump room, a pipe-flushing room and an assembly room.

Two units which include the electric motor of the NRM-450/100 pump with oil tank and STs-1.5/l1 separator for oil filtration, are located in the pump room. This equipment is controlled from a console placed outside the pump room. Oil enters the pipe and hydraulic parts flushing benches through filters installed on the pump delivery pipeline. The benches are equipped with two collectors and fittings which permit flushing of the pipes and hydraulic parts of different conditional opening (from $D_u = 6$ mm to $D_u = 70$ mm). The pipes are flushed with AU oil regardless of the mark of the operating oil of the system, which eliminates the need to replace the oil in the tanks when flushing pipes of different systems. Six pipe sections ("runs") up to 100 meters long, assembled from pipes subject to flushing, can be flushed simultaneously. The oil is given the flow rate which provides turbulence of flow in the flushed pipes as a function of the pipe diameter and length. There is a table in the section to determine the required oil pressure as a function of the length of the flushed sections and of the

conditional opening. Therefore, workers engaged in pipe flushing do not have to make any calculations to establish the necessary parameters. A single "length" is flushed within an average of 3-4 hours. Specially manufactured polyethylene caps which are then sealed are placed on the ends of each pipe.

The assembly room is explosion-proof and has efficient ventilation which provides excess pressure of 0.95 Pa. According to the requirements placed on the rooms for conservation, final flushing and testing of hydraulic equipment, the walls in them are covered with tile, while the floor is laid in ceramic tiles. All the incoming hydraulic equipment is unpacked here and preliminary finishing, flushing, testing and packing are carried out. All the hydraulic equipment is again subjected to unpacking and flushing in the shop immediately prior to installation of the ship, which permits a reduction of the periods of preparing the ship for dockside tests.

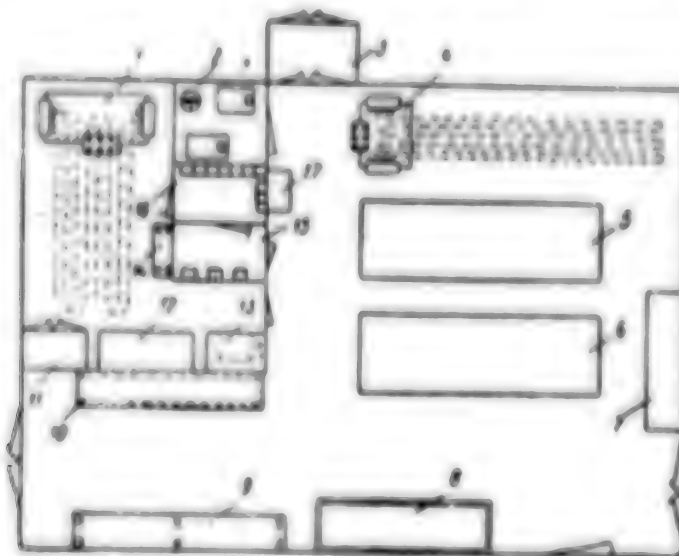


Figure 2. Diagram of Section for Assembly and Flushing of Pipe "Lengths": 1--bench for flushing fittings, hydraulic equipment and "lengths" of pipe with two collectors and filter block; 2-- pump room with two pump units and separator; 3--vestibule; 4--bench for flushing pipe "lengths" with two collectors and filter block; 5--bench for installation of pipes on caps; 6--bench for disassembly and assembly of large hydraulic equipment; 7--work bench; 8--platform for unpacking hydraulic equipment; 9--racks for tools and equipment; 10--tanks with AU oil; 11--cabinet for exchange stock of filter elements; 12--bench for reconstruction of fittings; 13--ultrasonic installation for cleaning filter elements; 14--rack for production connectors--15--washroom; 16--locker room; 17--"80G-904" bench for oil filtration

An ultrasonic installation has been installed in the assembly room for cleaning the filters and a replaceable stock for rapid replacement has been organized. There are two filter blocks each in the stationary and portable flushing benches and if one of them is contaminated (a check is made by pressure gauges), a switch is made to the second block. The filter elements in the contaminated block are replaced with clean ones and the contaminated filters are sent for ultrasonic cleaning. Continuous flushing of pipe "lengths" until complete cleaning of them is thus provided.

The integrity of the caps and seals is checked on the pipes coming to the ships for installation. If the seal is damaged or is absent, the pipe is sent to the shop for a second chemical treatment and flushing. Measures are undertaken during installation of the pipes to prevent mechanical impurities from falling into the inner cavity of the pipes. The closed sections of the pipes are flushed after installation of the pipes of the hydraulic system according to schemes developed by the chief technicians department. The schemes are carried out so that the pipes are subjected to minimum disassembly during capping. Flushing is carried out by means of production benches manufactured on the basis of displacement pumps and also screw and vane pumps. There are 16 portable benches at the shipyard which provide flushing of all the hydraulic systems simultaneously. This operation continued for approximately three weeks on the ship "Kapitan Smirnov."

Introduction of flushing the pipes of the hydraulic systems and creation of a specialized hydraulic section in the installation-finishing shop permitted a reduction of the laboriousness of manufacture and installation of the hydraulic systems by 26,300 standard-hours and made it possible to achieve a saving of 23,000 rubles.

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EXPERIENCE WITH FASHIONING AND FINISHING OF SHIP SPACES BY USING
'CHERNOMORIT'

Leningrad SUDOSTROYENIYE in Russian No 3, 1980 pp 50-51

[Article by A. D. Granik and A. I. Pigin]

[Text] A number of new design and technological solutions was employed in design and construction of the gas turbine ship "Kapitan Smirnov." One of them is the modular system of fashioning and finishing the ship spaces. The essence of the system is the use of a limited number of elements for constructing the spaces, which permitted transfer of a significant volume of work to the finishing shops (i.e., to specialized production conditions) and a sharp reduction of the adjusting and finishing operations onboard the ship. Those types of finishing operations such as carpentry, insulation and painting are essentially absent or have a minimum volume. The use of the modular system made it possible to reduce by 30-35 percent the laboriousness of work in fashioning the ship spaces.

The modular system used in construction of the gas turbine ship provides for a multiplicity factor of 100 mm of the dimensions of the ship spaces and also the elements of fashioning and finishing them. The nomenclature and number of standard elements for constructing the spaces, manufactured by industrial methods, were reduced to a minimum. This provides a high quality of work in finishing the spaces, interchangeability of parts and good repairability of the ship spaces during operation.

In order to realize to the maximum extent the advantages of the modular system of construction, the elements for fashioning, finishing and equipping the spaces must meet a number of conditions. The technology of the manufacture should correspond to industrial methods of production and the physico-mechanical properties related to their functional designation should not cause difficulties in installation on the ship and should meet the regulations and requirements placed on shipbuilding materials. The new construction and finishing material "chernomorit" (inventor's certificate No 464477) was developed at the Black Sea Shipyard during solution of these problems and industrial production of the panels was organized for constructing the ship spaces (Figure 1). Specifically, these panels are used on the gas

turbine ship "Kapitan Smirnov" to fashion the bulkheads and side planking. Prior to this, similar panels were used in construction of large refrigerated trawlers of the "Pulkovskiyy Meridian" class and gave a good account of themselves under operating conditions. The use of "chernomorit" panels was coordinated with the USSR Registry.

Figure 1. Section for Manufacture of "Chernomorit" Panels

"Chernomorit" panels are three-ply structures 20 mm thick. The inner element--a corrugated sheet 6-7 mm thick (the height of the corrugations is 12 mm)--is manufactured by the method of pressing from wood-fiber sheets impregnated with synthetic resins and antipyrenes, which increase the fire resistance of the material. Laminated plastic material on a phosphate base four mm thick is glued on both sides of this sheet. The panel material is strong, water resistant and nonhygroscopic.

The panels have sufficiently good stiffness which permits them to be installed on the ship essentially without lathing. The "chernomorit" panels are secured to the deck by means of channel iron manufactured from sheet material; they are secured to the deckhead by suspension on strainer bars using hooks (Figure 2). The panels having special grooves in the ends are connected to each other by means of keys manufactured by the method of pressing from binder-impregnated sheet asbestos. The high holding strength of the screw at any point of the panel plane (at any point up to 2,900-3,900 N for a M4 screw) permits equipment to be attached securely with self-tapping screws without resorting to installation of any fillers and special fasteners.

One of the advantages of "chernomorit" panels is that they simultaneously perform the functions of a construction and finishing material. Any colors, drawing or texture can be given to the panel surfaces by selecting the corresponding decorative paper during their manufacture. The required openings for sockets and other fittings installed on the ship without any additional treatment of the panels is provided in them. Cutting of the panels around the perimeter, cutting out openings and other similar operations are carried out under shop conditions.

Panels manufactured at the plant from laminated plastic materials four mm thick, produced by the Black Sea Shipyard, are used for planking the cabin ceilings. All the required holes for attachment of lights, loudspeakers, fire alarms and so on are made in the panels beforehand.

The panels are attached to the deck by means of lathing, while they are joined to each other by a key plate inserted into grooves on the ends of the panels. The deckhead planking panels around the perimeter of the space rest on channel iron measuring 45 X 28 X 4 mm, attached to the bulkheads made of "chernomorit" panels. Due to the absence of camber and sheer of the deck in the region of the living superstructure, the panels do not require finishing when they are installed on the ship. The design of the

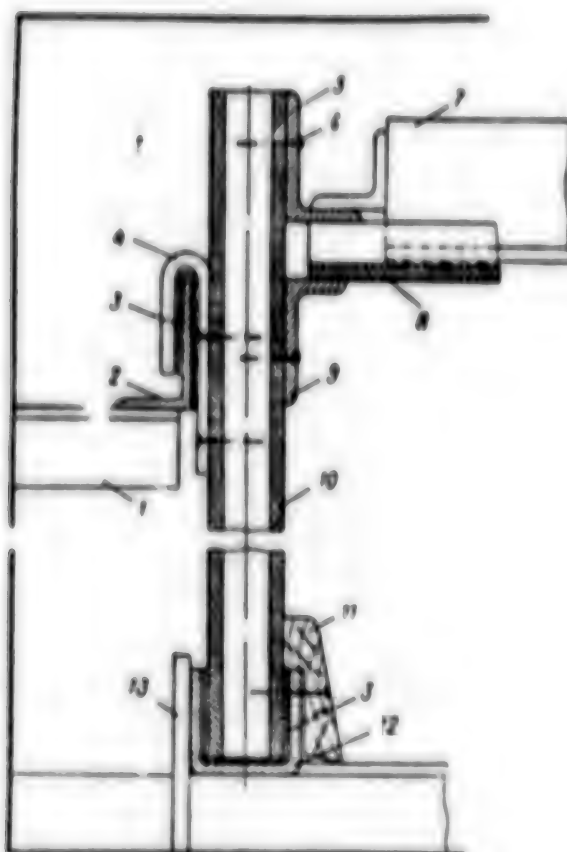


Figure 2. Assemblies for Attachment of "Chernomorit" Panel and Deck-head Panels: 1--support; 2--lathing stringer bar; 3--spacer; 4--hook; 5--stringer bar; 6--screw; 7--removable tee-bar; 8--deckhead panel; 9--facing stringer bar; 10--"chernomorit" panel; 11--skirting board; 12--channel iron; 13--plate

deckhead planking is removable, which facilitates repair operations. The technological feature of fashioning the spaces is the circumstance that installation of the bulkheads and the deckhead planking can be carried out independently of each other. There are three groups of typical living spaces on the ship "Kapitan Smirnov": 40 single-berth cabins with individual lavatories, five block cabins for the middle-level command personnel and two block cabins for senior command personnel. Standardization of the cabins reduced the volume of design documentation and in turn made it possible to standardize the elements for constructing the spaces. "Chernomorit" panels of seven dimensions are used to manufacture the bulkheads between cabins and three dimensions of panels are used for the deckhead planking.

According to the Regulations for Classification in Construction of Ocean-Going Ships of the USSR Registry, published in 1970, the material of the "chernomorit" panels and other panels is fire-resistant. The degree of its

its combustibility was checked by the calorimetric method. It should be noted that fire-retaining structures (type V according to the same Regulations), which tolerated standard fire-resistance tests, were manufactured from "chernomorit" panels. This confirms the rather high fire-resistant properties of the material. "Chernomorit" panels and those made from fire-resistant laminated plastic material manufactured at the plant were authorized by the Main Sanitary-Epidemiological Administration of the Ministry of Health of the USSR for installation on ships.

A new modification of the panel material for construction of ship spaces has now been developed at the Black Sea Shipyard. Having approximately the same physicomachanical and technological qualities as "chernomorit," this material has tolerated tests for noncombustibility according to the Rules of the Registry, published in 1977, and have been recognized as noncombustible. The "chernomorit" of the new modification will be used in construction of ships after organization of industrial production.

A significant element in construction of ship spaces is the porthole opening, which is a niche surrounding the side porthole and which covers the space between the planking and side of a ship. Production of three standard dimensions (1,600 X 960 X 180, 1,660 X 960 X 200 and 860 X 960 X 200 mm) of plastic openings having devices for hanging curtains and a depression in the form of a dripcock was organized at the shipyard. Porthole openings of impact-resistant, self-muffling polystyrene of mark SNP-S are manufactured by the pneumatic shaping method. Three standard dimensions of porthole openings provide fashioning of all cabins and other spaces of ships under construction.

The use of plastic porthole openings instead of metal made it possible to release workers of several specialties--tin workers, welders and fitters-assemblers, while the progressive technology of manufacture and installation of them reduced the laboriousness of work.

Thus, introduction of the modular system of fashioning and finishing ship spaces produces a significant saving provided that construction elements manufactured by industrial methods are used. It is in this manner that production of "chernomorit" panels, having high structural, technological and decorative qualities, was organized. The use of these panels and also laminated plastic panels for the deckhead planking and the use of plastic porthole openings facilitate installation operations on the ship.

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USING SPECIAL TOOLING IN PRODUCTION OF A PILOT SHIP

Leningrad SUDOSTROYENIYE in Russian No 3, 1980 pp 51-52

[Article by V. M. Zusa]

[Text] The characteristics of constructing the hull and equipping the pilot ship "Kapitan Smirnov" required development and use at the Black Sea Shipyard of special tooling which contributed to reduction of the length of pre-way, way and finishing periods of constructing the ship. A number of specific examples is presented below.

Bending dies, which eliminate the loss of transverse strength of the sections during bending, which is achieved by special spring-loaded rotary grabs, were used in vertical and horizontal presses in the hull shop during manufacture of the frame planking from symmetrical and asymmetrical strip-bulb sections with high walls.

The presence of a large number of mechanized automobile hoisting platforms with perforated flooring five mm thick made it necessary to develop and use a special die to bore several holes 50 mm in diameter during a single working pass of the press. The die was equipped with six punches having a device for variable cutoff, which permits the holes to be punched with different spacing. Introduction of this die made it possible to significantly reduce the metal machining time.

To reduce metal consumption of the tooling, the volumetric sections of the bulb fairing and the forepeak were assembled on curved beds having disconnects to provide transportability of them. Connection of the bed parts was cotter type, which contributes to fast installation and disassembly of the bed.

It became necessary to use replaceable multiple-use technological pillars in shaping the ship hull on the ways because of the presence of unsecured deck bulkheads. This reduced the laboriousness of installation and removal of the pillars and reduced the consumption of metal for temporary reinforcing structures.

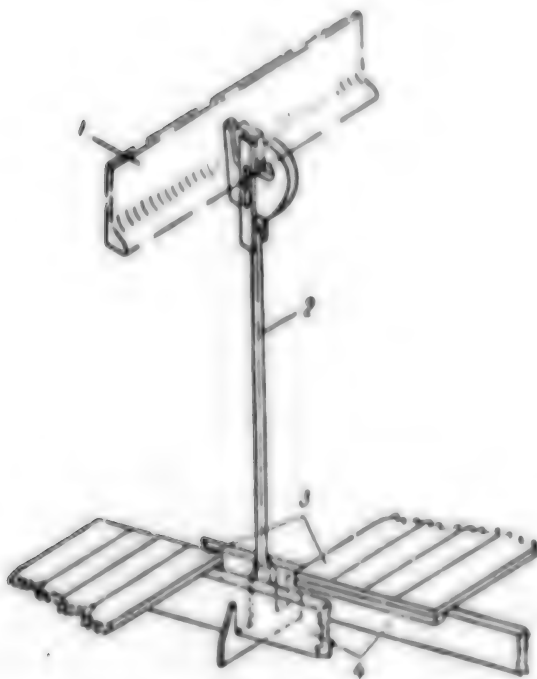


Figure 1. Assembly for Attachment of Deck Construction Timbers:
1--strip-bulb framing of ship; 2--suspension; 3--flooring panels; 4--supporting beams

The significant height of the ship cargo spaces and the large volume of work on the deckheads made it necessary to create special suspensions for the construction timbers having mechanical attachment to the deck strip-bulb framing. The holding device of the suspension is distinguished from known designs by its simplicity (it consists of one four parts) and provides reliable attachment of the suspension to the framing (Figure 1). Multiple-use flooring panels of boards 32 mm thick are used to save lumber for structural timbers. It will obviously be feasible in the future to use platforms which move along rail tracks attached to the deck framing as structural timbers in the holds and tweendecks of the ship.

Deck sockets for securing containers are provided on all decks on the "Kapitan Smirnov." The work was carried out by means of marking and adjusting gauges created at the shipyard due to the rigid tolerances on the coordinates of placing these sockets (Figure 2). The sockets welded into the deck were tested by a specially designed and manufactured device.

The shafting lines were installed by using special structural timbers with working platforms which can be moved on rails laid on the ways parallel to the shafting lines. The need to complete the work on installation of the screw-rudder group within compressed deadlines led to the development of special tooling. A framework structure in which the screw was secured was used to install the screws. It is equipped with a carriage moved by winches

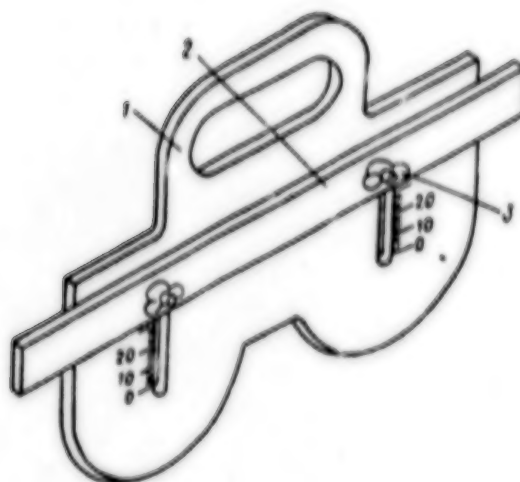


Figure 2. Marking Gauge for Installation of Container Sockets: 1--body; 2--adjusting plate; 3--nut

along rail tracks of the timbers mentioned above. Four turnbuckles, which hold the screw in a suspended state by means of band loops were used to change the position of the screws in height with respect to the shafts. The screw is moved in the horizontal plane by hydraulic jacks installed near the base of the supporting columns. The same principle is the basis of tooling for installation of the rudder blade (Figure 3). Guides with carriages for installation of the pin and its nut are provided on the supporting columns. There are platforms and ladders to perform the operations. The use of this tooling in combination with the movable timbers contributes to accelerated completion of all types of work in the stern overhang of the ship hull.

A special bed consisting of three pairs of supporting elements had to be used in assembly of the ramp sections and the middle pair of supports has separate adjustment in height for bringing the ramp sections closer to each other. Production benches which were connected directly to the actuating mechanisms of the ship covers were manufactured to ensure operation of the ramp, bulkhead covers and decks prior to final installation of the permanent hydraulic systems. The materials and articles were delivered inside the ship to the inclined stern ramp by wheeled equipment during construction of the ship. Production sections by which entry of wheeled equipment onto the ramp with the ship in different position with respect to the dock was used for this during the early stages of ramp installation.

The enumerated tooling is far from a complete list of the entire complex of devices created by the technicians and designers during pre-production and construction of the pilot ship "Kapitan Smirnov." At the same time, as indicated by experience, further improvement of technology and introduction of new technical solutions are required for successful construction of this series of ships.

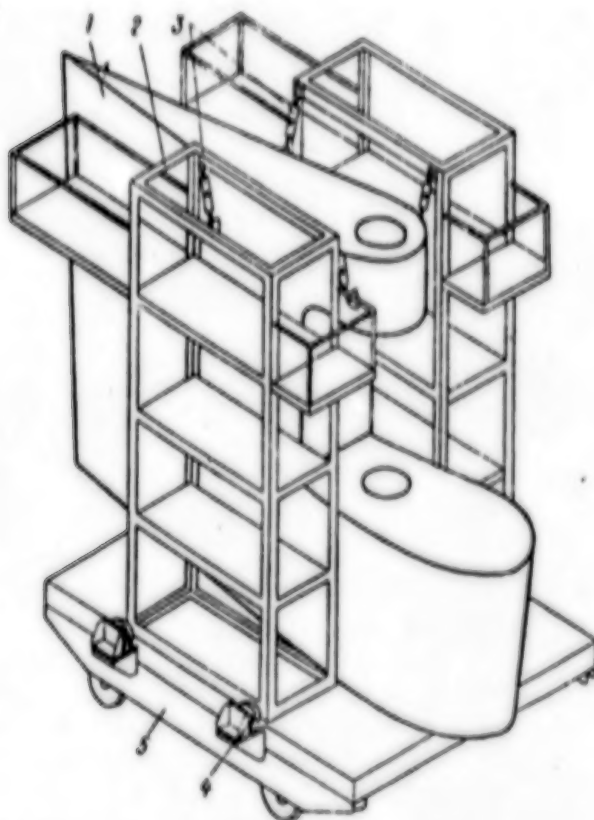


Figure 3. Device for Setting Up an Installation of Rudder Blade:
1--rudder blade; 2--columns; 3--turnbuckles; 4--hydraulic
jacks; 5--carriage

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